



TECHNICAL TRAINING PUBLICATION

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ELECTRONIC CIRCUIT PRACTICES

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1. INTRODUCTION.

1.1 In telecommunication network equipment, most components are mechanically and electrically connected by soldered joints, and to ensure operational reliability it is essential that these joints should be dependable.

1.2 Electronic components were first soldered into circuits about 1920 and since that time standards and techniques of production and maintenance have been continually reviewed. The techniques described in this paper are a summary of the results of this experience and reflect the stringent standards required in the modern electronics industry.

1.3 Although some of the information in this paper is of general interest only, it is provided so that the reasons for preferring selected techniques and materials can be understood.

2. SOLDERS AND FLUXES.

2.1 GENERAL. Soldering is the joining of metals using solder as a filler material and bonding agent. Unlike welding, which depends upon melting and fusion of the metals to be joined, soldering depends upon continuous intimate contact between the solder and metal surfaces, and upon mechanical interlocking of the solder with the irregular surface texture of the metals. This intimate contact is termed 'wetting'. The reliability of the joint depends upon the effectiveness of the bond at each interface (Fig. 1).

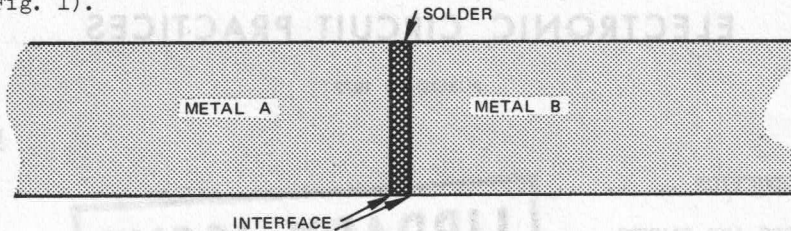


FIG. 1. TWO METALS BONDED BY SOLDER.

2.2 Solder is normally a tin-lead alloy, although combinations with metals such as bismuth, indium, antimony, cadmium, and silver may be used. The alloy chosen and the technique most suitable for a particular work depend upon the characteristics of the alloy and the nature of the work.

2.3 TEMPERATURE CHARACTERISTICS. Tin melts at 232°C , and lead melts at 327°C , and the temperature at which an alloy of these two metals liquifies depends upon the ratio of the metals. Fig. 2 shows the temperature at which tin, lead, and the range of alloys become liquid. The soldering temperature is usually 37°C to 65°C above this temperature to ensure that the solder is fluid, assisting the wetting action.

When heated, most tin-lead alloys pass through a plastic region before becoming liquid. Fig. 2 shows that different alloys have different temperature ranges for the plastic region, and that alloys with approximately 15% tin or more, and approximately 5% lead or more are solid below 183°C .

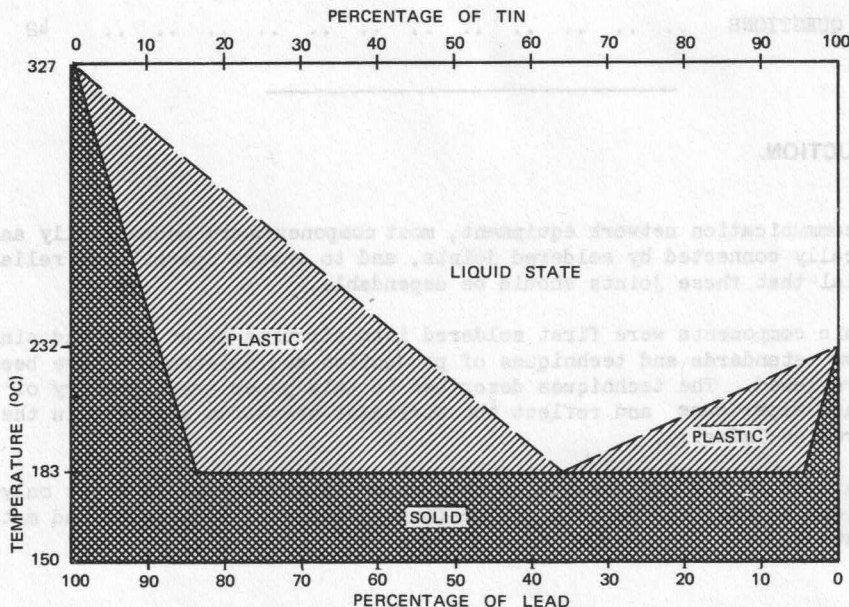


FIG. 2. SOLID, PLASTIC AND LIQUID REGIONS OF TIN-LEAD ALLOYS.

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Fig. 3 shows the variation in plastic region for various tin-lead alloys ranging from 50% tin - 50% lead to 80% tin - 20% lead. The ratio of metals in the alloy is usually expressed with the percentage figure for tin first, followed by the percentage figure for lead; for example, 60% tin - 40% lead is normally written as 60 - 40 or as 60/40. Note that the 63-37 alloy passes directly from solid to liquid with no plastic region. Alloys with this characteristic are termed 'eutectic alloys' (in this case, eutectic solder) and the temperature at which the change from solid to liquid takes place is termed the 'eutectic point'. In this case the eutectic solder is composed of 63 tin-37 lead and the eutectic point is 183°C.

Eutectic solder is not commonly used on electronic equipment, as it is extremely susceptible to fracturing at the moment of solidification. This can be caused by any slight movement of the joint at that instant.

Solder alloys having a slight plastic range are normally used, and 60 tin - 40 lead solder is most commonly chosen. The plastic range of this alloy is 5°, which is relatively insignificant, provided it is recognised and care is taken not to move the joint while the solder is in this stage, otherwise a physically weak and electrically unreliable joint results.

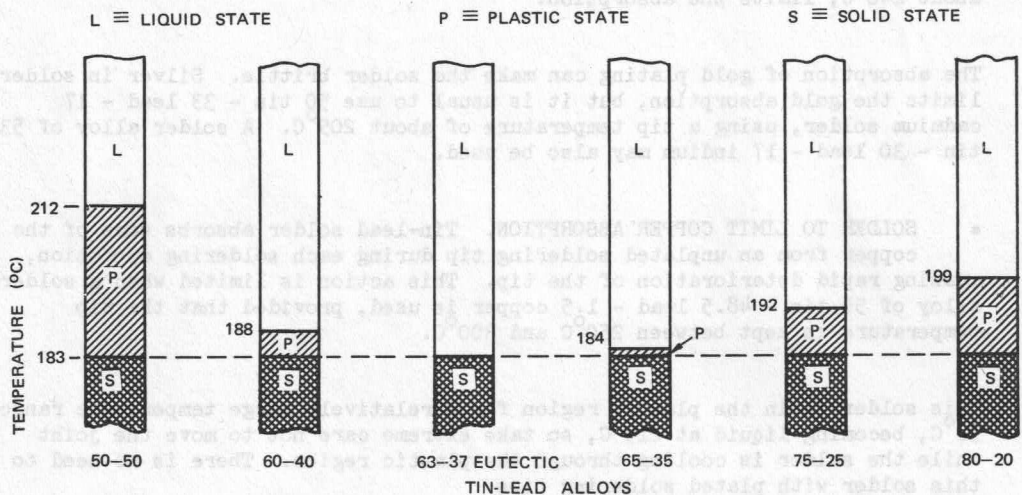


FIG. 3. RELATIVE PLASTIC RANGES OF SOME TIN-LEAD ALLOYS.

2.4 ELECTRICAL CHARACTERISTICS. Any soldered joint must have minimum electrical resistance, and be able to carry the current without creating areas of heat. For example, when soldering a round wire to a flat surface it should be in direct contact with the surface (Fig. 4a) otherwise the solder carries all the current (Fig. 4b). Solder has a conductivity approximately 11% of copper, increasing the resistance of a joint when solder is the conductor.

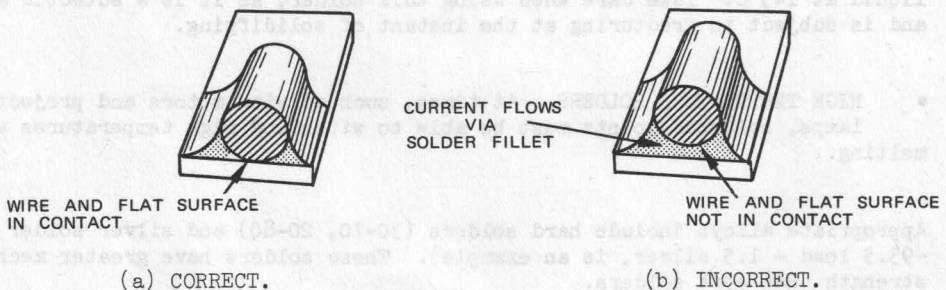


FIG. 4. ROUND WIRE SOLDERED TO A FLAT SURFACE.

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2.5 MECHANICAL CHARACTERISTICS. When solid, the solder should be able to withstand stress without fracturing. These stresses can be caused by differences in heat expansion rates of the joined metals or between the metals and supporting materials. Solders with less than 60% tin content are liable to fracture.

2.6 SPECIAL-PURPOSE SOLDERS.

- **SOLDER FOR PLATED LEADS AND TERMINALS.** A small amount of the plating on the metal being joined is absorbed into the solder. Normally this is of no concern, and the usual tin-lead solder can be used. When absorption of the metal is a problem, a special-purpose solder or a different soldering technique must be used.

The absorption of silver plating can leave a surface that is difficult to wet. Solder with 2% silver (low melting point solder), used with a tip temperature of about 240°C, limits the absorption.

The absorption of gold plating can make the solder brittle. Silver in solder limits the gold absorption, but it is usual to use 50 tin - 33 lead - 17 cadmium solder, using a tip temperature of about 205°C. A solder alloy of 53 tin - 30 lead - 17 indium may also be used.

- **SOLDER TO LIMIT COPPER ABSORPTION.** Tin-lead solder absorbs some of the copper from an unplated soldering tip during each soldering operation, causing rapid deterioration of the tip. This action is limited when a solder alloy of 50 tin - 48.5 lead - 1.5 copper is used, provided that the tip temperature is kept between 250°C and 300°C.

This solder is in the plastic region for a relatively large temperature range of 32°C, becoming liquid at 215°C, so take extreme care not to move the joint while the solder is cooling through the plastic region. There is no need to use this solder with plated soldering tips.

- **LOW TEMPERATURE SOLDERING.** Some components and materials may be damaged when the heat necessary for normal 60-40 solder is applied. Also, it may be necessary to solder on to a joint that is already soldered, without melting the existing solder joint. In these cases a low melting point solder is used.

An example of such an alloy is 50 tin - 33 lead - 17 cadmium, which becomes liquid at 145°C. Take care when using this solder, as it is a eutectic alloy and is subject to fracturing at the instant of solidifying.

- **HIGH TEMPERATURE SOLDERS.** At times, such as with motors and projection lamps, soldered joints must be able to withstand high temperatures without melting.

Appropriate alloys include hard solders (30-70, 20-80) and silver solder (5 tin - 93.5 lead - 1.5 silver, is an example). These solders have greater mechanical strength than soft solders.

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2.7 FLUX. Flux is applied to the area being soldered to remove the non-metallic tarnish produced on the metal and solder surfaces by exposure to the air. The tarnish is a barrier to satisfactory wetting.

2.8 CHARACTERISTICS OF FLUX. A flux should:

- Provide a liquid cover over the metal to exclude air.
- Dissolve any tarnish on the metal surfaces, and carry this away.
- Be displaced from the metal by the fluid solder.
- Assist the solder in spreading.
- Release acid at soldering temperature.
- Be inactive at normal temperature and not cause corrosion of soldered surfaces.
- Be compatible with the metals being soldered, the solder alloy being used, and the soldering temperature.

Note that waxes, greases etc. cannot be removed by flux; these are removed with suitable solvents before flux is applied.

2.9 ROSIN FLUX. The most suitable flux for soldering on electronic equipment is based on rosin, which is obtained from the gum of pine trees. Pure rosin is not generally used, as its action is too slow and it is relatively ineffective. To improve the tarnish removing property of pure rosin, and to increase the maximum temperature at which the flux remains active, substances called 'activators' are added. At soldering temperatures, the decomposition of the activators liberates an acid that dissolves the tarnish faster than does pure rosin. This type of flux is called 'activated flux.'

2.10 ROSIN-CORED SOLDER. Flux is usually applied to the work as a core along the length of the solder wire. This ensures that the correct proportion of flux to solder is applied and that the solder is applied to a tarnish-free surface. Flux has a lower melting point than solder, and remains active up to typical melting point temperatures of solder. At soldering temperatures the flux is de-activated.

2.11 USING FLUX. The flux is applied to the work area, and when heated it prepares the surfaces for application of the molten solder. When soldering with cored solder the heat passes through the solder to the flux, melting it first and allowing it to flow on to the work at the optimum temperature. When the solder melts, the increase in temperature de-activates the flux, limiting the possibility of corrosion. It is essential to thoroughly heat activated rosin during soldering to ensure the complete decomposition of the activators, otherwise they remain corrosive at normal temperatures.

As rosin is effective only up to typical soldering temperatures, it should not be applied to the work on a hot soldering tip. This rule applies whether the flux is used as a paste, as a liquid, or as the core of a section of rosin-cored solder. The tip temperature is liable to evaporate or de-activate the flux.

2.12 CORROSION. Corrosion refers not only to the chemical damage of metallic conductors, but also to the build up of materials between the conductors, permitting current leakage. Apart from flux activator residues, corrosive deposits can be caused by human perspiration (which produces more corrosive materials than any other factor), as well as by fumes, packing materials, and storage conditions. These deposits should be removed by suitable solvents, not by scratching, as this can cause further damage.

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2.13 TACKINESS. Apart from its potentially corrosive characteristics, flux residues may also be tacky, tending to collect dust and other matter which could cause current leakage. Normally, this problem occurs only with mass-production techniques, or with the separate application of flux. Use an approved solvent to remove any unwanted flux.

2.14 SOLVENTS. When flux residues are considered potential hazards, they should be removed with a suitable solvent. These residues should not cause concern with normal soldering work, and solvents should only be applied when the residues have not been fully subjected to soldering temperatures. This is usually only the case when the flux is applied separate from the solder.

Apply the solvent with a bristle brush or spray to dissolve the flux residue. Remove the solution with an industrial wiping tissue or other absorbent material that leaves no fluff or lint, using a clean part of the tissue each time to prevent flux being reapplied to the work.

Do not use large quantities of solvent, and do not dip the work in solvent when switches, variable resistors and non-sealed parts having moveable contacts (for example, relays) are part of the assembly. The dissolved rosin may enter spaces from which it cannot be removed.

Use solvents with extreme care as they can be toxic.

3. SOLDERING TOOLS.

3.1 GENERAL. Fig. 5 illustrates typical soldering tool parts. When the tip is inserted in the heating element and electrical energy is applied, the tip is heated for application to the work.

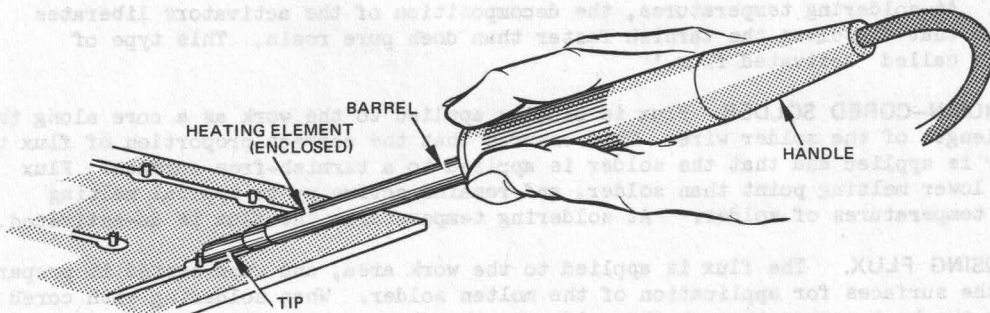


FIG. 5. TYPICAL SOLDERING TOOL.

3.2 SELECTION OF A SOLDERING TOOL. The correct soldering tool is selected according to the requirements of the finished joint, the characteristics of the work being soldered, and the nature of the solder.

3.3 CORRECT TIP TEMPERATURE. Soldering tools are normally classified by wattage; however, this can be misleading, as other factors including variations in tips, efficiency and manufacturers' designs must also be considered. Maximum tip temperature occurs when a constant tip temperature is being maintained. When this temperature is too high or too low the resulting joint may be physically and electrically unsatisfactory, and damage may be caused to the work. The tip temperature is usually listed in soldering tool catalogues, and may also be marked on the tool.

Fig. 6a shows how a correctly selected and heated tool produces a good joint, whereas Fig. 6b shows how insufficient heat results in a poor joint. The tool tips only are shown in these diagrams. Insufficient tip heat may be due to other factors, including power rating of the heating element, efficiency of the heat path, etc.

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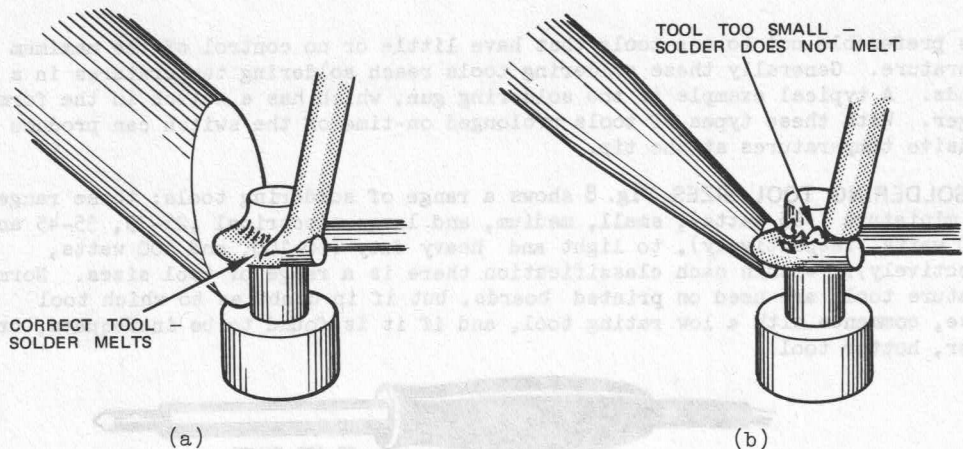


FIG. 6. SELECTION OF CORRECT SOLDERING TOOL.

Temperature control is sometimes used to minimise the possibility of damage that can be caused by excessive tip temperature. This may be achieved by selecting the correct soldering tool and tip, or with the use of controls.

One method of controlling the tip temperature is shown in Fig. 7. A temperature sensing element at the base of the tip attracts a permanent magnet when the tip is cold. This action pulls the power switch on, causing the tip to be heated. When the tip reaches its operating temperature the sensing element releases the magnet, which pushes the switch off.

When the tip cools slightly, the magnet is again attracted reconnecting the power to the heating element. Using tips with elements having differing operating temperatures allows the tip temperature to be controlled; elements are available in the range of 260°C to 430°C .

A soldering stand, having temperature sensing elements controlling the supply of energy to the heating element, is another means of monitoring and controlling tip temperature.

The tip temperature for use on electronic components depends upon the type of device being soldered and upon the total length of time that the tip is applied during each operation. For continuous work, as in manufacturing, a tip temperature of 420°C is satisfactory; for intermittent use, as in servicing, a tip temperature of 380°C is adequate.

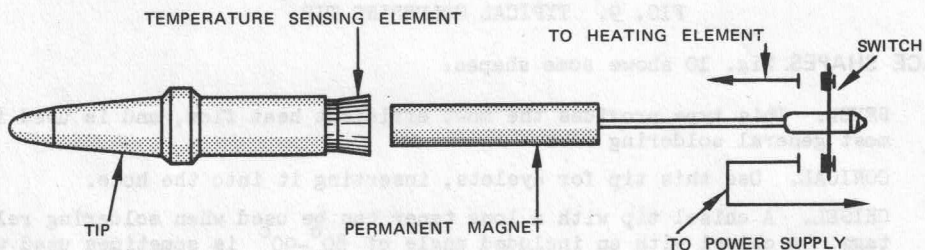


FIG. 7. TEMPERATURE CONTROL USING TEMPERATURE SENSING ELEMENT.

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It is preferable not to use tools that have little or no control of the maximum tip temperature. Generally these soldering tools reach soldering temperatures in a few seconds. A typical example is the soldering gun, which has a switch in the form of a trigger. With these types of tools prolonged on-time of the switch can produce excessive temperatures at the tip.

3.4 SOLDERING TOOL SIZES. Fig. 8 shows a range of soldering tools; these range from miniature (<25 watts), small, medium, and large electrical (25-35, 35-45 and 45-60 watts, respectively), to light and heavy duty (60-100, and 100 watts, respectively). Within each classification there is a range of tool sizes. Normally miniature tools are used on printed boards, but if in doubt as to which tool to use, commence with a low rating tool, and if it is found to be inadequate, try a larger, hotter tool.

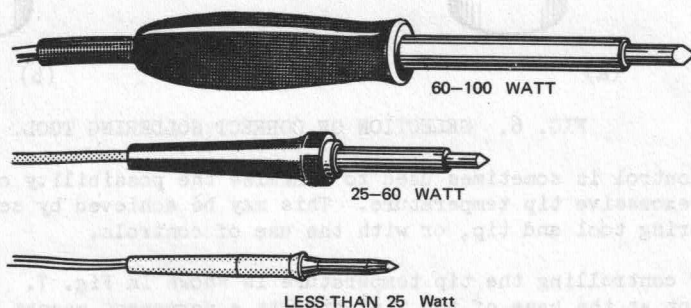


FIG. 8. A RANGE OF SOLDERING TOOLS.

3.5 RECOVERY RATE. This is the time taken by the tip to regain its maximum temperature after the heat has been removed during soldering. The recovery rate is affected by the heat output of the element, the size and shape of the tip, and by the amount of heat taken by the work.

3.6 SOLDERING TIPS. These are also called 'bits'. The soldering tip conducts the heat from the element to the work. Fig. 9 shows a typical tip and the terms commonly used for the various parts.

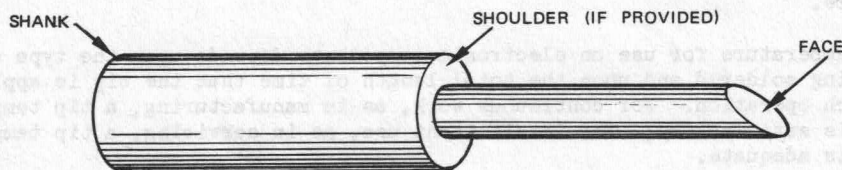


FIG. 9. TYPICAL SOLDERING TIP.

3.7 FACE SHAPES. Fig. 10 shows some shapes.

- **BEVEL.** This type provides the most efficient heat flow, and is used for most general soldering work.
- **CONICAL.** Use this tip for eyelets, inserting it into the hole.
- **CHISEL.** A chisel tip with a long taper can be used when soldering relay tags. A chisel with an included angle of 80° - 90° is sometimes used when soldering on a printed board; one face is placed against the conductor, and the other is placed against the component lead.

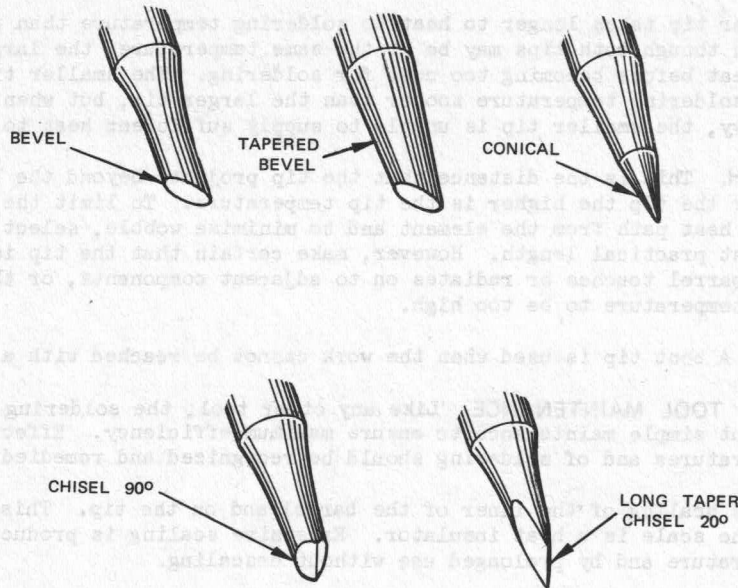


FIG. 10. SOLDERING TIP SHAPES.

3.8 TIP MATERIAL. Tips are made of copper, copper alloy, or iron-plated copper as shown in Fig. 11.

Bare (unplated) tips transfer heat more efficiently to the work than plated tips, but unless copper-saturated solder is used to limit absorption of copper into the molten solder, the usable life is shorter than that of plated tips.

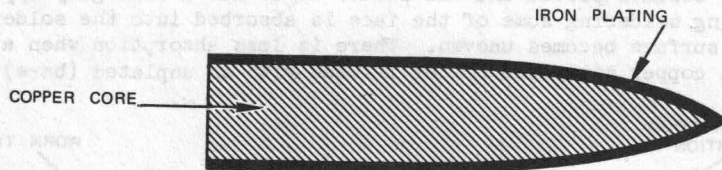


FIG. 11. PLATED TIP.

3.9 TIP DIAMETER. The internal diameter of the element determines the diameter of the shank. This in turn determines the amount of heat that may be transferred along the tip. When this is too great, the tip is tapered or stepped (Fig. 9).

The diameter of the face determines the rate of heat transferred to the work. A small tip has a higher temperature but smaller heat reserve than a large tip. Generally, the more heat that the work is likely to absorb, the larger the tip diameter should be.

For instance, when soldering electronic equipment, the face diameter should be chosen after considering the size and spacing of the conductors (particularly on printed boards), terminals, and components. The tip diameter should not be such that it obscures the work or damages adjacent parts.

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A larger diameter tip takes longer to heat to soldering temperature than does a small tip. Even though both tips may be at the same temperature, the larger tip supplies more heat before becoming too cool for soldering. The smaller tip, however, reheats to the soldering temperature sooner than the larger tip, but when the work load is too heavy, the smaller tip is unable to supply sufficient heat to the work.

3.10 TIP LENGTH. This is the distance that the tip projects beyond the barrel.

The shorter the tip the higher is the tip temperature. To limit the distance of the heat path from the element and to minimise wobble, select the tip with the shortest practical length. However, make certain that the tip is not so short that the barrel touches or radiates on to adjacent components, or that it causes the tip temperature to be too high.

3.11 BENT TIP. A bent tip is used when the work cannot be reached with a straight tip.

3.12 SOLDERING TOOL MAINTENANCE. Like any other tool, the soldering tool requires frequent but simple maintenance to ensure maximum efficiency. Effects of high operating temperatures and of soldering should be recognized and remedied.

Heating produces scaling of the inner of the barrel and on the tip. This reduces efficiency as the scale is a heat insulator. Excessive scaling is produced by high operating temperature and by prolonged use without descaling.

To remove the scale, take the tip from the barrel and tap both barrel and tip onto a firm surface (for example the top of the work bench). This should be done regularly, preferably at the completion of each soldering session. Before removing a plated tip from a barrel, wait until it is quite cold.

3.13 SOLDERING TIP MAINTENANCE. For maximum transfer of heat from the tip to the work, the tip face must be smooth and coated with a shiny layer of rosin-free solder. A face in this condition is said to be "tinned" (Fig. 12a).

With use the face becomes pitted and the solder layer has a dull grey appearance (Fig. 12b). During soldering some of the face is absorbed into the solder and with repeated use the surface becomes uneven. There is less absorption when a plated tip is used, and when copper saturated solder is used with an unplated (bare) tip.

TIP IN GOOD
CONDITION



(a)

WORN TIP



(b)

FIG. 12. TIPS IN GOOD AND WORN CONDITIONS.

- **PLATED TIP.** When the tip is cold, minor surface irregularities can be repaired with very fine emery cloth. Care must be taken not to remove the plating from the tip. After cleaning, heat the tip and apply a layer of solder to the face.

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Relatively large pitting indicates that areas of plating have been removed and as repairs to the face would only remove further plating, tips in this condition should be replaced.

For normal maintenance, the molten solder on the face should be regularly replenished while the tip is hot. Clean the face with a damp, fine textured sponge or a fine textured wire brush (Fig. 13). Do not overwipe the tip as this removes all the molten solder. After cleaning the tip reapply a fresh coating of solder. It may be necessary to wait a few seconds to allow the tool to return to soldering temperature after the quench from the sponge. Plated tips should have an excess of solder on the face while not being used.

- **UNPLATED TIP.** Pitting can be removed by filing (dressing) the face with a fine single-cut file. Remove the tip from the tool and place it in a vice. Do not file excessively as this reduces the heat content of the tip and also increases the tip temperature. Insert the tip, heat it and apply a thin layer of solder to the face. Unplated tips should not have an excess of solder on the face when not in use. Do not pull the tip out from the barrel to compensate for the reduced tip length, as this overheats that section of the heating element not in contact with the tip, reducing its life and also producing excessive scaling.

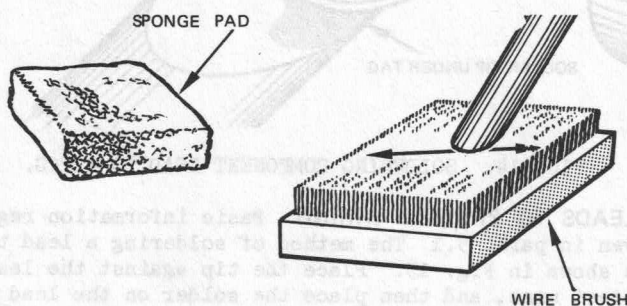


FIG. 13. REGULAR TIP CLEANING DURING USE.

4. SOLDERING TECHNIQUES.

4.1 GENERAL. Once the appropriate materials and equipment have been selected, they should be used in such a way as to produce mechanically and electrically reliable joints.

Basic techniques are described in this Section; these should be applied as appropriate to the nature of the job.

4.2 BASIC TECHNIQUE. The soldering tool should be switched on and the tip allowed to reach the required temperature before being applied to the work. Some tools take several minutes to reach the soldering temperature while others take only a few seconds.

Apply the tip face to that part of the work having the greatest mass, provided that it is not the most heat sensitive section.

After lying idle, a soldering tip is covered with a thin layer of hot solder tarnish; the metallic surfaces to be soldered are tarnished also. When the tip is applied to the work, the heat has to pass along an inefficient heat-transfer path, which prolongs the soldering operation. During this time, the metals are conducting heat from the area, further increasing the soldering time, and increasing the possibility of damage to components and to the board. This problem is overcome by applying a bit of flux and solder to the junction of the tip and the area being heated. The flux at the tip removes the tarnish, rapidly heating a small area. The molten solder improves the thermal contact between the face and the work by wetting both surfaces and by filling the minute air spaces formed between them. The air trapped in the spaces would otherwise act as a poor heat conductor.

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When the area of the joint is at the soldering temperature, apply the solder to it.

Do not apply too much solder, as this can conceal an unsound joint, or too little solder, as this can produce a mechanically or electrically poor joint.

4.3 SOLDERING LEAD TO A TAG. Fig. 14 shows how to solder a lead to a tag.

Place the tip against the tag, as this is the part with greatest mass and then apply the solder, first to the junction of the face and the work, which improves the heat transfer path, and then to the area of the joint.

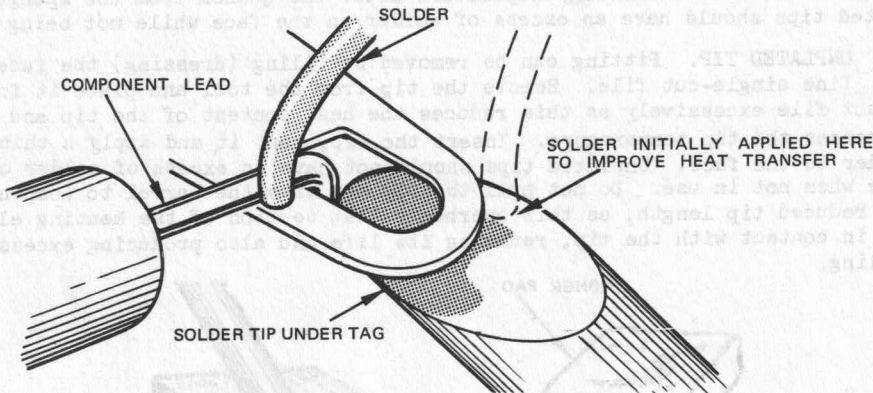


FIG. 14. SOLDERING COMPONENT LEAD TO A TAG.

4.4 SOLDERING LEADS TO PRINTED WIRING. Basic information regarding printed boards is given in para. 5.1 The method of soldering a lead to a conductor on a printed board is shown in Fig. 15. Place the tip against the lead as this is the part with the greatest mass, and then place the solder on the lead at the junction of the lead and the tip face. The molten solder spreads down the component lead, pushing the flux ahead of it

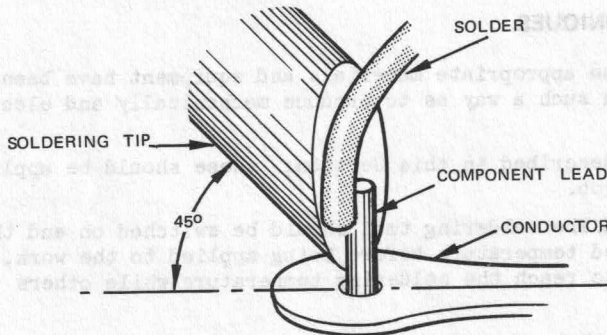


FIG. 15. SOLDERING A LEAD TO A PRINTED WIRING.

4.5 REMOVAL OF SOLDER AND HEAT. Remove the soldering tip from the work after the solder has been removed. This ensures that the solder has been melted and that all flux activators have been subjected to soldering temperatures, reducing the likelihood of corrosion after cooling.

Allow the solder to cool naturally, do not cool it by blowing. Make certain that there is no movement of the joint while the solder is solidifying, otherwise a poor quality joint may result.

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4.6 EXCESS HEAT.

- **PRINTED BOARDS.** The copper conductors are attached to the board by an adhesive that loses its holding qualities when excess heat is applied. This causes the conductor to lift off the board. To prevent this happening, apply the iron for the minimum time, using the lowest practical soldering temperature. Heat problems are kept to a minimum when the surfaces to be soldered are clean.

Expansion and contraction of double sided boards during soldering can cause fracturing of the soldered joints (Fig. 16). When excess heat is applied, the soldered joint on the reverse side of the board is stressed because of the expansion of the board. The joints on both sides are then stressed permanently inwards when the board contracts, as this contraction occurs some time after the solder has solidified.

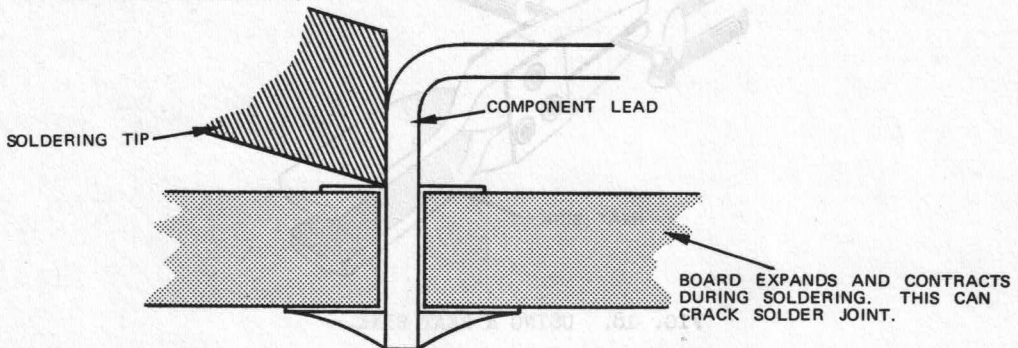


FIG. 16. FRACTURING SOLDERED JOINT ON DOUBLE-SIDED BOARD.

- **COMPONENTS.** Limit the radiation of heat on to the board and components by keeping the soldering tip and body away from them. If necessary, place a shield between the tool and adjacent components (Fig. 17).

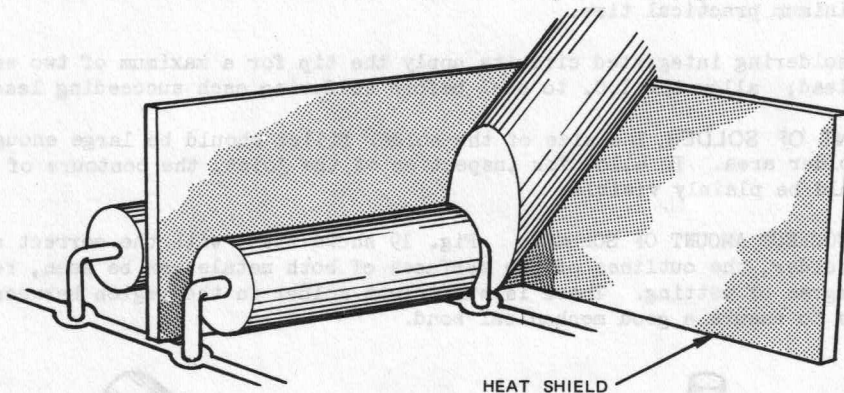


FIG. 17. USING A HEAT SHIELD.

When it is thought that heat may damage components, use a heat sink. These are commercially available, although a screw-driver blade or pliers may be used. When using pliers, it is preferable to use a pair having plain faces, as serrations reduce the area in contact with the lead. Leave the heat sink on the lead for several seconds after removing the soldering tip; allow the heat sink to cool before using it again. Make sure that the heat sink is placed between the soldering tip and the component (Fig. 18).

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Apply the soldering tip for the minimum time, but do not make this time too short or the joint may be insufficiently wetted.

Use low melting point, rosin cored solder. 60 tin - 40 lead, 63 tin - 37 lead or 65 tin - 35 lead is adequate for normal use, although a special low melting point solder having a melting temperature of 145°C (50 tin - 33 lead - 17 cadium) can be used when required.

If available, use an aerosol component-chiller.

Keep the component leads as long as practicable.

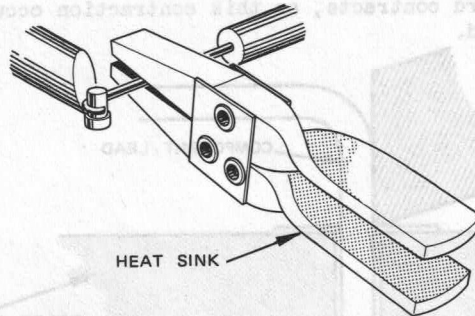


FIG. 18. USING A HEAT SINK.

- **SEMICONDUCTORS.** Excess heat can permanently damage the crystal lattice structure of semiconductors and alter the distribution of impurity atoms.

Silicon transistors are not as heat sensitive as earlier germanium transistors, and may be soldered without using a heat sink, provided that heat is applied for the minimum practical time.

When soldering integrated circuits apply the tip for a maximum of two seconds to each lead; allow the I.C. to cool before soldering each succeeding lead.

4.7 AMOUNT OF SOLDER. The size of the solder fillet should be large enough to fill the solder area. To allow for inspection of the joint, the contours of the metals should be plainly visible.

- **CORRECT AMOUNT OF SOLDER.** Fig. 19 shows that, with the correct amount of solder, the outlines of the surfaces of both metals can be seen, revealing the degree of wetting. There is sufficient solder in the region between the metals to ensure a good mechanical bond.

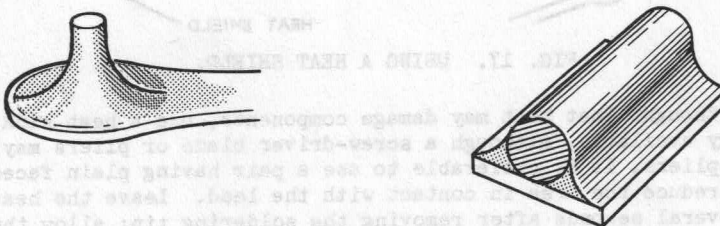


FIG. 19. CORRECT AMOUNT OF SOLDER.

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- **INADEQUATE SOLDER (Fig. 20).** This results in a mechanically weak joint. The termination is liable to go open electrically under mechanical stress, such as that caused by vibration, and that due to contraction and expansion with variations in temperature.

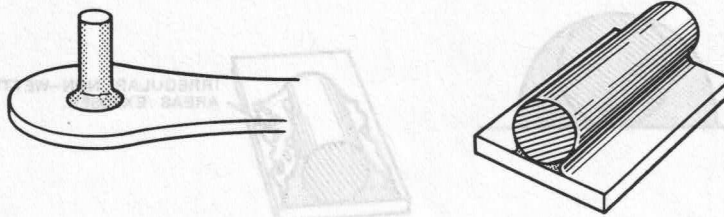


FIG. 20. INADEQUATE SOLDER.

- **EXCESS SOLDER (Fig. 21).** Excess solder does not improve the strength or current-carrying capacity of the joint, and as it may conceal that the surfaces are inadequately wetted, it is classified as a poor joint.

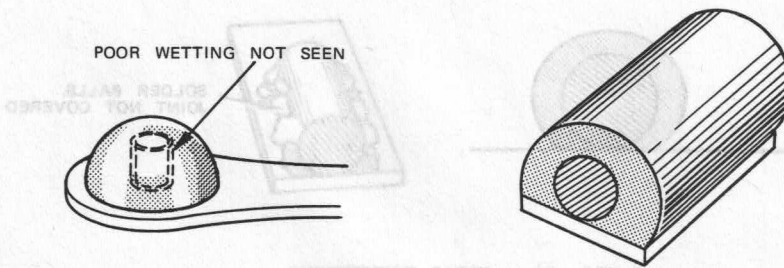


FIG. 21. EXCESS SOLDER.

- 4.8 ANGLE OF CONTACT.** The angle at which the solder meets the surface of the metal is a measure of the quality of the soldered joint.
- 4.9 TOTAL WETTING** is indicated by the solder being feathered as it meets the metal surface (Fig. 22). The solder surface is bright, with few or no pinholes. This condition is the ideal.

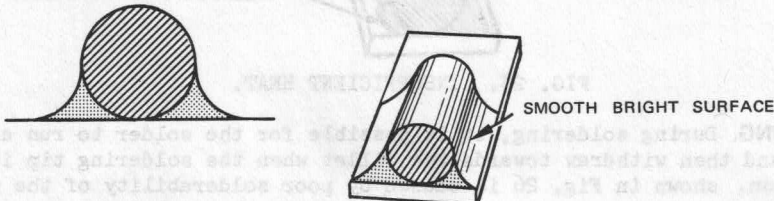


FIG. 22. TOTAL WETTING.

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4.10 PARTIAL WETTING. When the joint is partially wetted, the solder runs only partially along the metal, or dewets (para. 4.13), meeting the metal surface abruptly (Fig. 23). This condition may be acceptable, provided the angle of contact is not too large. The solder surface is not continuous, with irregular, round, nonwetted areas exposed.

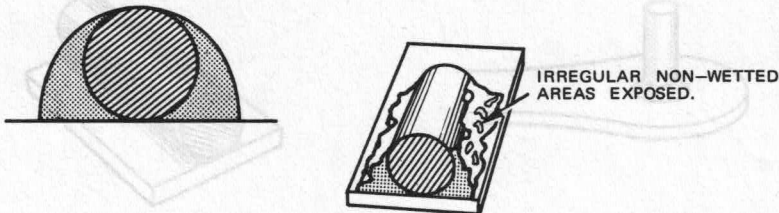


FIG. 23. PARTIAL WETTING.

4.11 TOTAL NONWETTING. When the joint is not wetted, the solder does not completely cover the surface and appears as droplets or balls (Fig. 24). This condition is completely unacceptable.

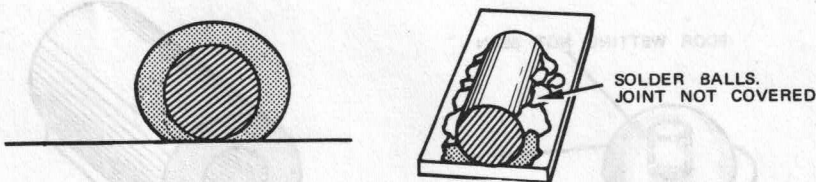


FIG. 24. TOTAL NONWETTING.

4.12 INSUFFICIENT HEAT. The angle of contact between the solder and metal surface is very large when insufficient heat is applied, as the solder solidifies before adequate wetting occurs (Fig. 25). The flux is not properly activated, and the work is covered with tarnish, allowing the solder to be pried loose. The surface of the solder is smooth and continuous. This condition is unacceptable.

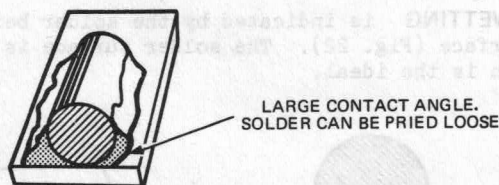


FIG. 25. INSUFFICIENT HEAT.

4.13 DEWETTING. During soldering, it is possible for the solder to run along the metal, and then withdraw towards the fillet when the soldering tip is removed. This condition, shown in Fig. 26 is caused by poor solderability of the metal. It is important not to try to overcome this condition by applying excess solder, as this can make it impossible for the solder to withdraw, concealing the poor solderability of the metal. To overcome dewetting, remove all traces of tarnish from the metals, and also any solder, before resoldering. The angle of contact between the solder and metal surface is very large.

ELECTRONIC CIRCUIT PRACTICES

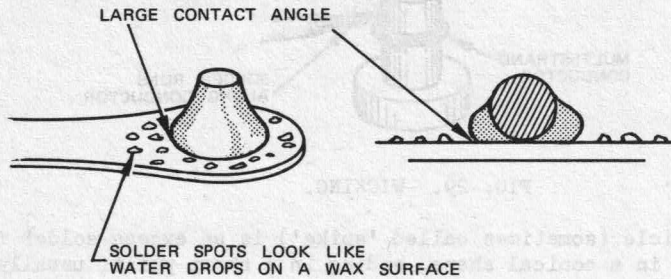


FIG. 26. DEWETTING.

4.14 COLD JOINT. The angle of contact is usually small, but the surface of the solder is frosty and granulated as shown in Fig. 27. This is caused by movement of the joint during soldering, and may be repaired by reapplication of heat, or by removing the solder and then resoldering. A cold joint may also be caused by solder running on to surfaces cooler than the soldering temperature.

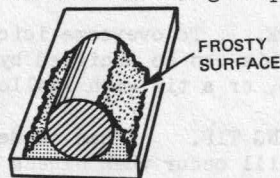


FIG. 27. COLD JOINT.

4.15 ROSIN BOND. In this case (Fig. 28) the angle of contact is usually large and the bond is achieved by a layer of solidified flux. There may be no electrical continuity, and little strength. The solder is continuous. The large angle of contact is caused by solder running onto surfaces cooler than the soldering temperature.

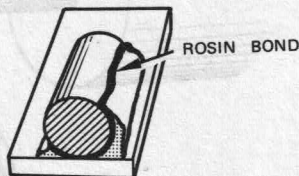


FIG. 28. ROSIN BOND.

4.16 WICKING. Applying excess solder, or heat for too long, can cause solder to run along the conductors of multi-strand cable (Fig. 29). This is called wicking and can be reduced by soldering faster, and by using a heat sink on the conductors.

The flux is pushed ahead of the solder as it moves along the conductor and if the flux reaches the cable sheathing it can be absorbed by the insulating material. As this flux has not been subjected to soldering temperatures, the activators remain corrosive and can cause physical deterioration of the insulation, and possibly current leakage.

Solder on the normally flexible wires makes them brittle, liable to break when the conductor is moved.

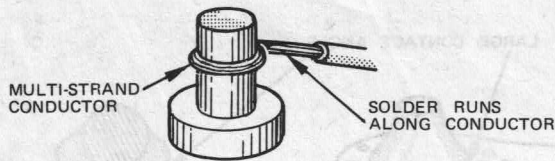


FIG. 29. WICKING.

4.17 ICICLING. An icicle (sometimes called 'spike') is an excess-solder formation which solidifies in a conical shape, ending in a sharp point, usually pointing in the direction in which the iron was withdrawn from the joint (Fig. 30). The tips can be removed by reapplication of the soldering tool, but as icicles may indicate poor wetting or dewetting this does not necessarily remedy the cause of the icicles.

- **POOR SOLDERABILITY OF THE METALS.** This condition can be recognised by poor wetting or dewetting at the edge of the icicle base. The small fillet size can be mistaken for good quality.
- **LOW SOLDERING TIME.** Icicles caused this way are rectified by lengthening the soldering time.
- **LOW SOLDERING TEMPERATURE.** To overcome icicles caused this way, use a hotter soldering tip. This can be achieved by using a tool with a higher wattage rating, a shorter tip, or a tip with smaller cross sectional area.
- **EXCESS SOLDER ON SOLDERING TIP.** When soldering time and temperature are adequate, icicles can still occur when excess solder is present on the soldering tip.

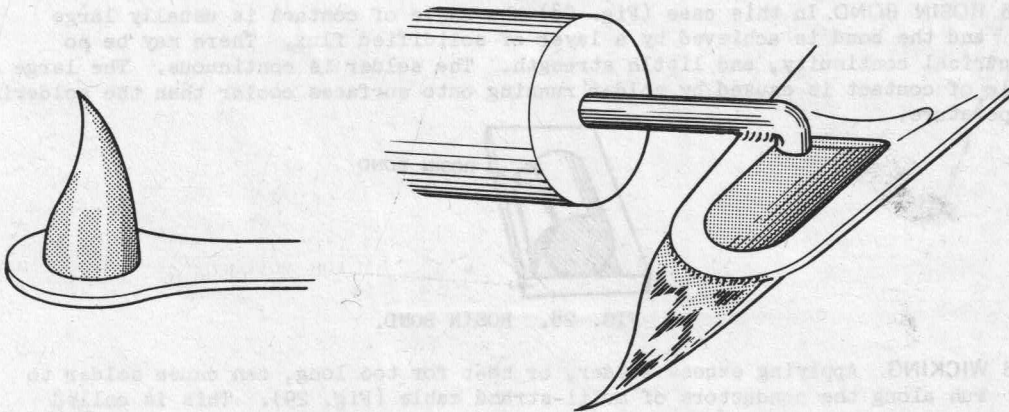


FIG. 30. ICICLES.

4.18 STRAY POTENTIALS. Semiconductor junctions are sensitive to potentials applied across them, and when this potential exceeds a critical value, the device can be destroyed. Soldering tools may have potentials at the soldering tip which exceed this critical value. These potentials are produced by resistive and capacitive coupling between the heater and soldering tip and between windings of the step-down transformer, when used.

4.19 REDUCTION OF EXTERNAL POTENTIALS. To remove the effect of any external earth-related potentials, completely disconnect the equipment from its voltage supply. Switching off the mains supply or the equipment mains supply switch may not protect the equipment, as the secondary could still be coupled to the active mains lead through the power transformer. Also, large-value capacitors in the voltage supply filtering circuit can retain relatively high charges for a considerable time.

When it is not possible to remove power from the equipment, reduce the external potentials by connecting a lead from the soldering tip to the equipment earth as shown in Fig. 31 (do not connect the lead to the mains earth potential). When using a soldering tool with a step-down transformer, use one that has an earthed electrostatic screen between the windings.

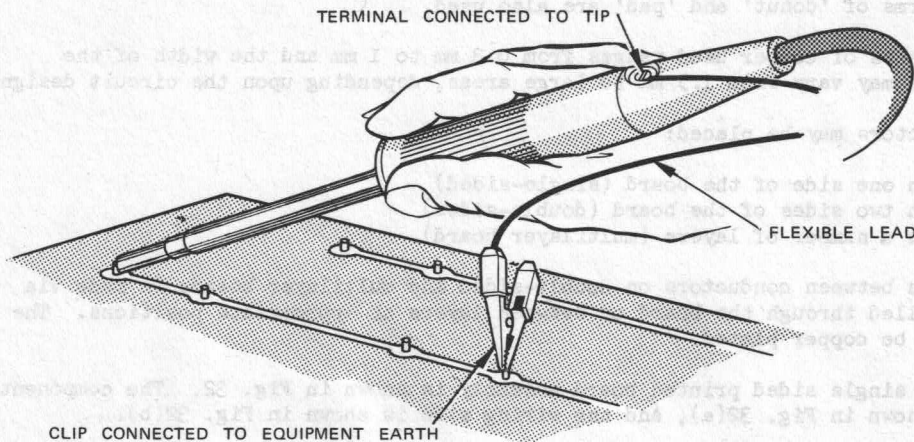


FIG. 31. FLEXIBLE LEAD TO EQUIPMENT.

- **SOLDERING MOSFET's.** Use a low voltage tool when soldering the lead that is connected to the gate section of a MOSFET, as the potential on a mains-operated tool can destroy the insulating film between the gate and substrate sections. Use a flexible lead connecting the tip of the soldering tool to the lead connected to the substrate before soldering the gate connection.

Do not untwist the MOSFET leads until it is to be used, but before doing so, wrap fine wire around all leads as close as possible to the case; some MOSFET's are supplied with wire wrapped around the leads. Remove the wire only after all the leads have been soldered into the circuit.

When using sockets, hold the MOSFET by the can and insert the substrate lead first. Never hold a MOSFET by its leads as the static electricity generated can destroy the insulating film. Take care when putting the device down while it is not connected in circuit, as MOSFET's are susceptible to damage from static electricity. For example, inserting a MOSFET into styrofoam generates over 200 volts of static electricity, destroying the device. Some MOSFET's have a diode internally connected in the gate lead to minimize susceptibility to damage from static electricity.

5. MOUNTING COMPONENTS ON PRINTED BOARDS.

5.1 PRINTED BOARDS. Printed boards (also known as printed circuit boards and printed wiring boards) simplify the manufacture of electronic equipment. They permit the mounting of components by unskilled persons and the whole board may be soldered in a single automated operation.

The printed circuit is formed by either embossing or selectively etching copper sheeting that is fixed to an epoxy glass or paper composition base material. The resultant pattern includes conductors and component terminal areas, with possibly printed edge board contacts, plated-through holes, printed components and printed contacts. The component terminal areas are termed 'lands', and because of their shape, terms of 'donut' and 'pad' are also used.

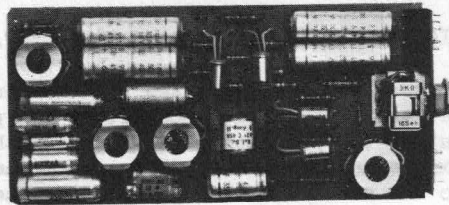
The thickness of copper used ranges from 0.3 mm to 1 mm and the width of the conductors may vary from 1.5 mm to large areas, depending upon the circuit design.

The conductors may be placed:

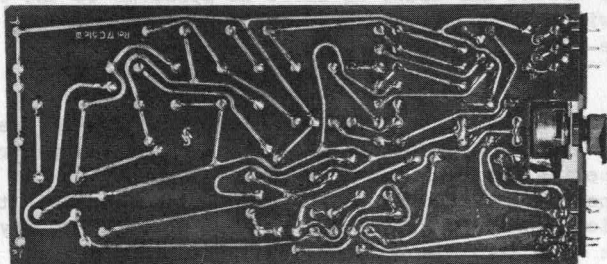
- on one side of the board (single-sided)
- on two sides of the board (double-sided)
- on a number of layers (multilayer board)

Connection between conductors on double-sided and multilayer boards is made via holes drilled through the board or between layers at appropriate positions. The holes may be copper plated.

A typical single sided printed board assembly is shown in Fig. 32. The component side is shown in Fig. 32(a), and the wiring side is shown in Fig. 32(b).



(a) Component Side.



(b) Wiring Side.

FIG. 32. PRINTED BOARD ASSEMBLY.

5.2 BENDING COMPONENT LEADS. Make the distance from the end of the body (or weld in the lead, if present) to the bend at least twice the diameter of the lead (Fig. 33). Generally the distance should be at least 2.5 mm. Bending the lead too close to the body can damage the lead-body seal and possibly break internal bonds. The distance from the body to the bend should be approximately equal on each lead.

The lead should be smooth with no kinks, sharp bends, tool marks, or deformations. It should enter the component and the mounting hole at approximately right angles.

Do not bend the leads on dual-in-line and flatpack integrated circuits either sideways or above the seating-plane as this can break the lead-body seal.

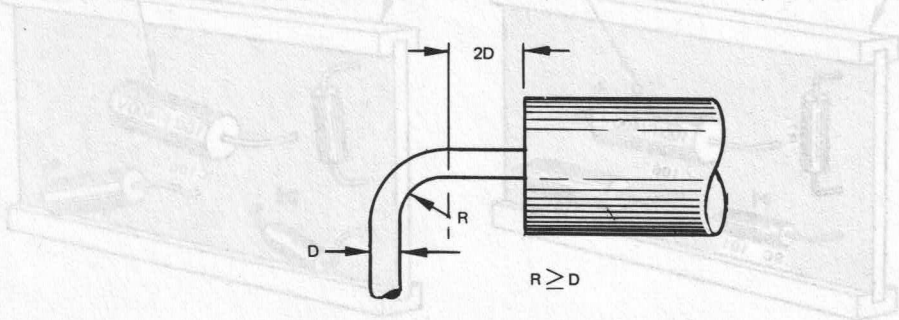
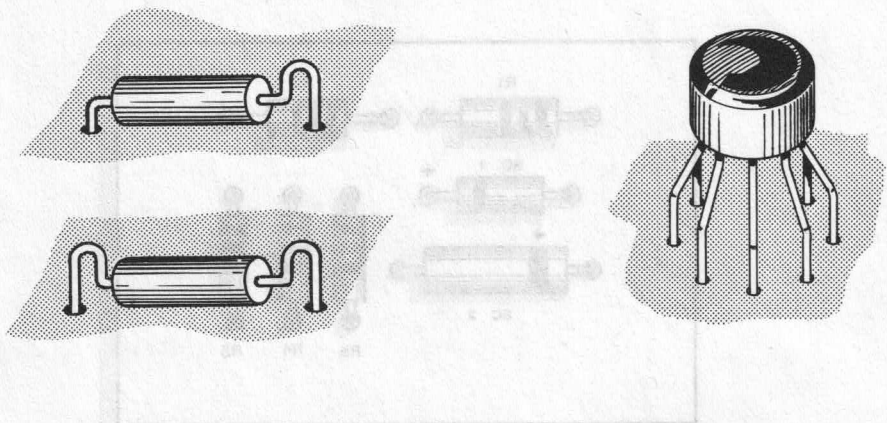


FIG. 33. BENDING COMPONENT LEAD.

5.3 STRESS RELIEF LOOPS. To prevent damage to the lead-body seals and to internal bonds, which could be caused by relative movement of component and board, a stress relief loop should be placed in at least one lead (Fig. 34).

When the component has two leads, as shown in Fig. 34a, the stress relief loop may be placed in either lead or in both leads. When the component has several leads, such as the integrated circuit in Fig. 34b, each lead should be similarly formed.



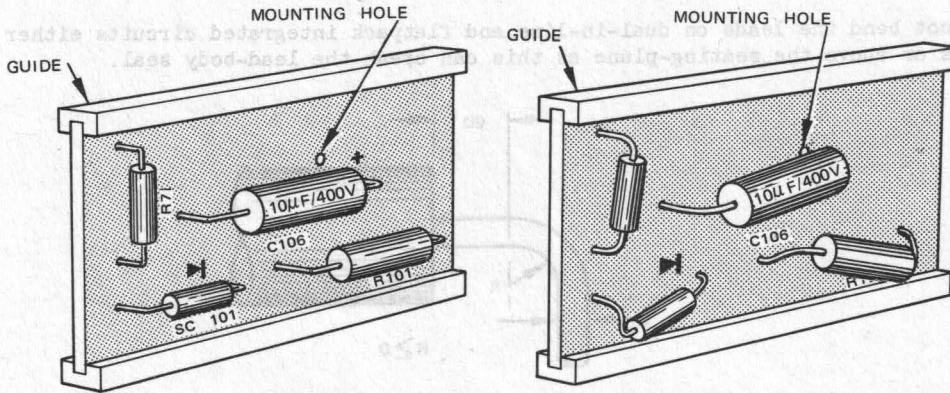
(a) Component with two leads

(b) Component with several leads.

FIG. 34. EXAMPLES OF STRESS RELIEF LOOPS.

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5.4 COMPONENT ALIGNMENT. Components are usually mounted on one side of the board, generally opposite the major circuit pattern. They should be mounted within the board outline, and clear any mounting hardware (Fig. 35). Place the components parallel to the board edge preferably with the major axis parallel to the direction of cooling air flow. Also, components should be placed mutually parallel or perpendicular to give an orderly appearance, and in such a manner that the board markings (legend) are clearly visible.



(a) Correct.

(b) Incorrect.

FIG. 35. COMPONENT ALIGNMENT.

5.5 COMPONENT ORIENTATION. Mount the components so that the component markings are easily read.

- HORIZONTAL ORIENTATION.** Horizontally mounted, non-polarised components should be so placed that all markings can be read from one position (Fig. 36). Position polarised components so that positive (+) and negative (-) symbols can be seen.

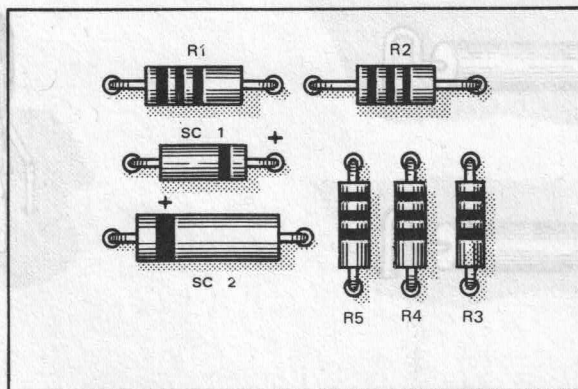


FIG. 36. HORIZONTAL ORIENTATION.

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- **VERTICAL ORIENTATION.** Place vertically-mounted, non-polarised components so that all markings read in the same direction. Position polarised components so that positive (+) and negative (-) symbols can be seen. (Fig. 37).

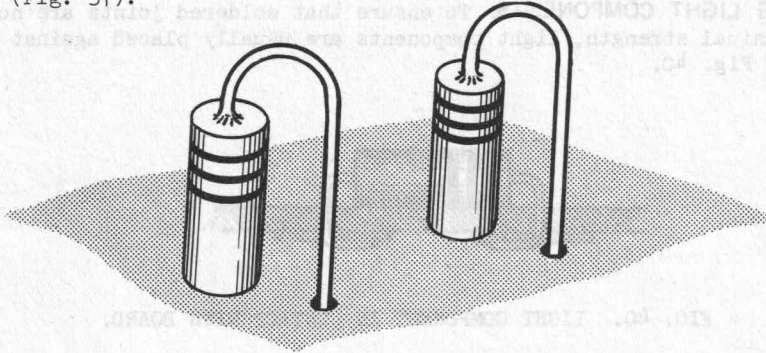


FIG. 37. VERTICAL ORIENTATION.

- 5.6 CLINCHED LEAD.** When the lead is bent over (clinched) on the wiring side, it should not project beyond the conductor surface, and should run parallel to the pattern as shown in Fig. 38. The clinch should hold the component.

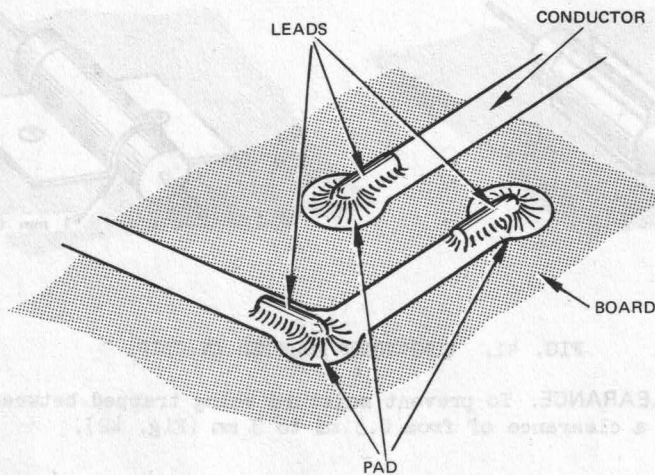


FIG. 38. CLINCHED LEADS.

- 5.7 UNCLINCHED LEAD.** When the lead is not bent over (unclinched) on the wiring side it should project beyond the copper surface by 1 mm to 2.5 mm. (Fig. 39).

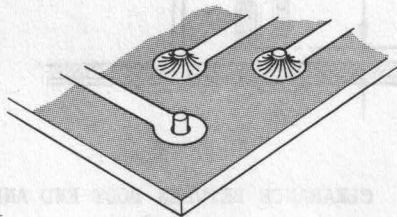


FIG. 39. UNCLINCHED LEADS.

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5.8 CUTTING LEADS. When cutting a semiconductor lead, place a 'shock absorber,' such as pliers, on the lead between the cutters and the device. If no protection is used, shock waves can travel along the lead and damage the welding or chip.

5.9 MOUNTING LIGHT COMPONENTS. To ensure that soldered joints are not relied on for mechanical strength, light components are usually placed against the board as illustrated in Fig. 40.

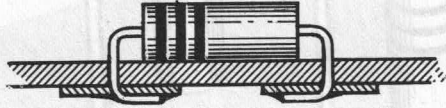


FIG. 40. LIGHT COMPONENT IN CONTACT WITH BOARD.

5.10 MOUNTING HEAVY COMPONENTS. Heavy components, and components dissipating more than 1 Watt should be mounted clear of the board by at least 1 mm and held in position with a suitable clamp as shown in Fig. 41, or with an epoxy adhesive.

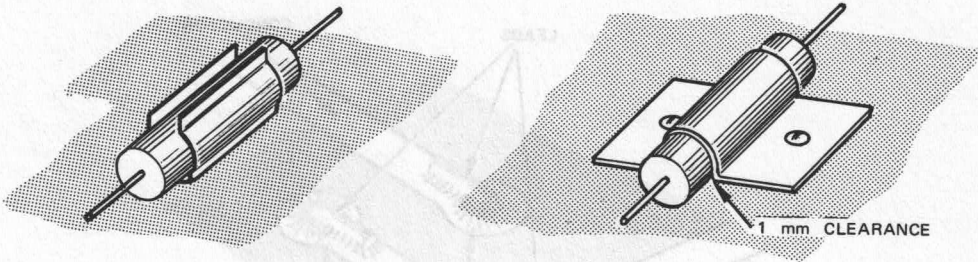


FIG. 41. COMPONENT MOUNTED IN CLIP.

5.11 VERTICAL CLEARANCE. To prevent moisture being trapped between the body and board, leave a clearance of from 0.5 mm to 3 mm (Fig. 42).

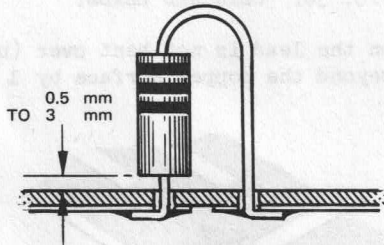


FIG. 42. CLEARANCE BETWEEN BODY END AND BOARD.

5.12 COATING ON LEADS. The coating on leads should not be removed from beyond the point where the lead enters the component and should not enter the hole (Fig. 43a). When there are terminal areas (lands) on the component side of the board, there should be a clearance of at least 2 mm between the circuit surface and end of the coating, as shown in Fig. 43b.

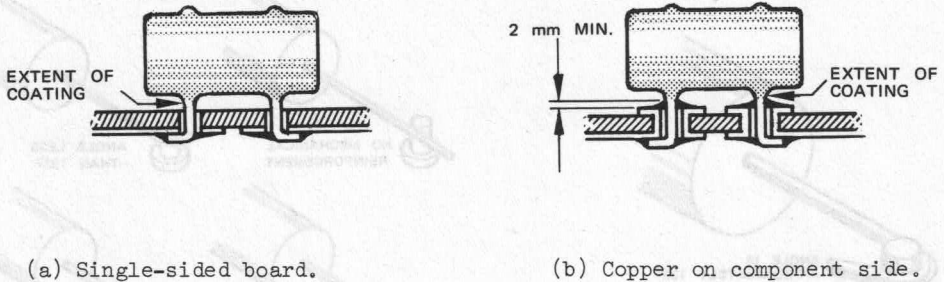


FIG. 43. MOUNTING COATED LEADS.

5.13 COMPONENTS BRIDGING CONDUCTORS. Fig. 44 shows how a metal-cased component can be insulated from conductors by encasing it with insulation tubing. The component should not be placed over any spike, such as a solder connection, as this can pierce the tubing. Components, whether in tubing or not, should not bridge more than one conductor unless the board surface is protected from moisture traps.

To prevent the formation of moisture under components bridging more than one conductor, a special coating is placed on the board where the component rests against the board. The component is mounted on the coating.

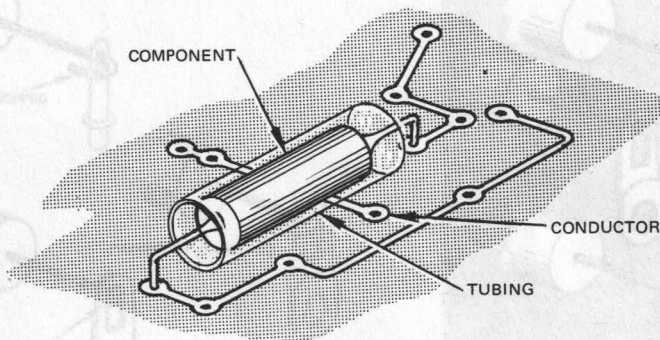
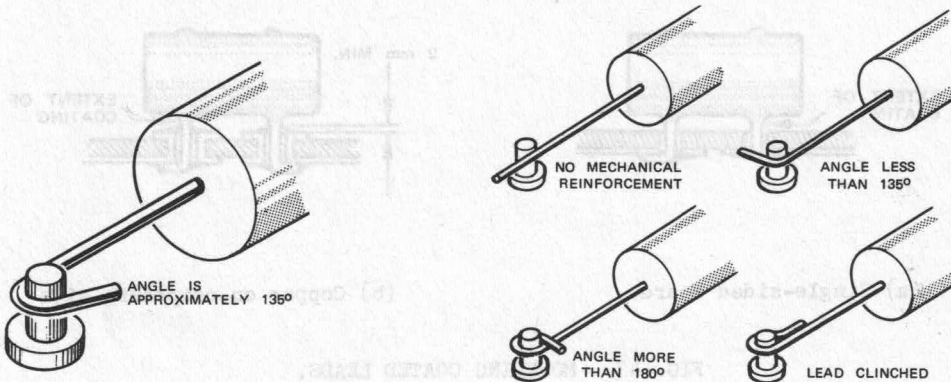


FIG. 44. METAL BODY COMPONENT CROSSING A CONDUCTOR.

6. MOUNTING COMPONENTS ON SOLDER TERMINALS.

6.1 TERMINATING LEADS ON TERMINALS WITHOUT HOLES. The lead should be bent around the terminal, making an angle of approximately 135° , as shown in Fig. 45a. The methods shown in Fig. 45b are incorrect as the angles are either too small, making the connection mechanically weak, or too great, making the lead difficult to remove.

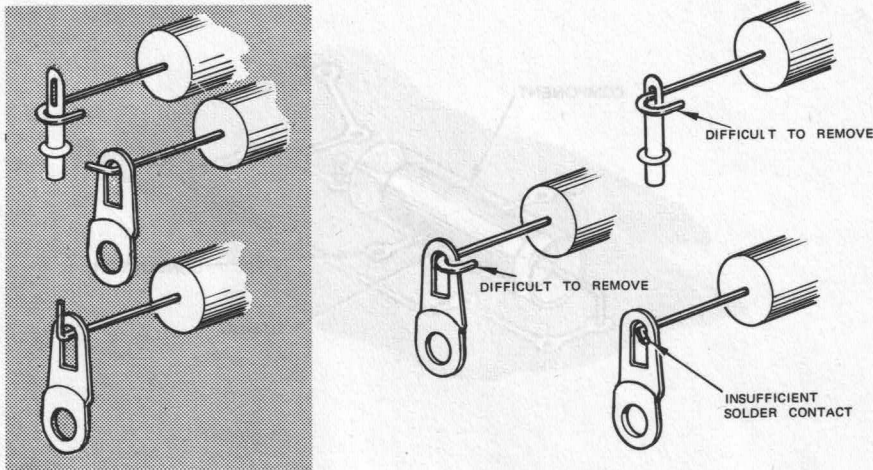


(a) Correct.

(b) Incorrect.

FIG. 45. USING SOLDER TERMINALS WITHOUT HOLES.

6.2 TERMINATING LEAD ON TERMINALS WITH HOLES. The correct methods of terminating leads on this type of terminal are shown in Fig. 46a. In each case, there is adequate contact between the lead and terminal for a good soldered joint, and the lead can be easily removed if necessary. The methods shown in Fig. 46b are incorrect because there is either insufficient contact for a good soldered joint or the lead is difficult to remove.



(a) Correct.

(b) Incorrect.

FIG. 46. USING SOLDER TERMINALS WITH HOLES.

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6.3 STRESS RELIEF LOOPS. Provide sufficient slack in one or more leads, such as shown in Fig. 47, when it is necessary to allow for any movement of the component. Movement may occur while the equipment is in use or during servicing. Whenever possible, make the bends in each lead approximately equal distance from the body.

6.4 BOTH TERMINALS WITHOUT HOLES. (Fig. 47). Bend each lead at the point corresponding to the position of the terminal. Tension it against the terminal during soldering.

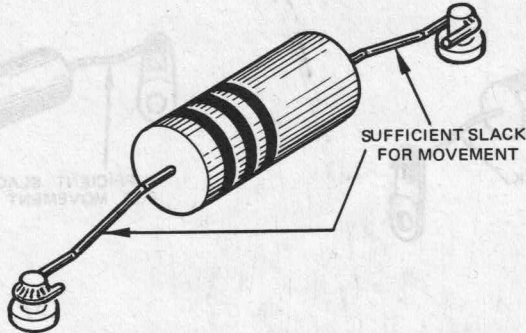


FIG. 47. MOUNTING: BOTH TERMINALS WITHOUT HOLES.

6.5 TERMINALS WITH HOLES.

- **APPROXIMATELY PARALLEL HOLES.** Bend each lead at right angles at the point corresponding to the position of the hole in the terminal (Fig. 48). Insert the lead without bending it again, otherwise the component will be difficult to remove.

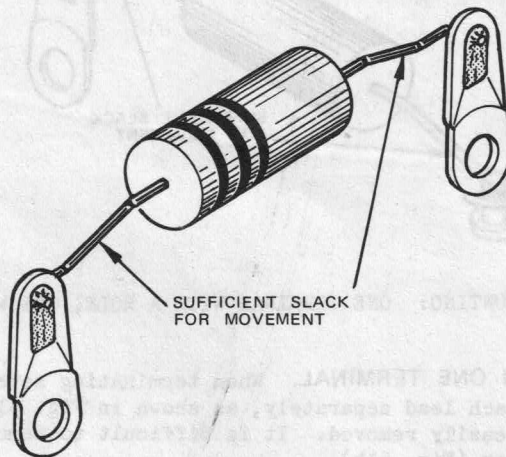


FIG. 48. MOUNTING: TERMINALS WITH PARALLEL HOLES.

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- **COAXIAL HOLES.** Fig. 49a shows a component mounted between terminals with coaxial holes. Bend one lead so that it passes along the side of the terminal away from the component. Pass the other lead through the hole without bending it again. Solder the bent lead first.

The terminals Fig. 49b are at a slight angle to one another. One lead is formed to pass along the side of the terminal closest to the component before entering the hole. Do not bend this lead after it enters the hole. Pass the other lead through the hole without bending it. Solder the bent lead first.

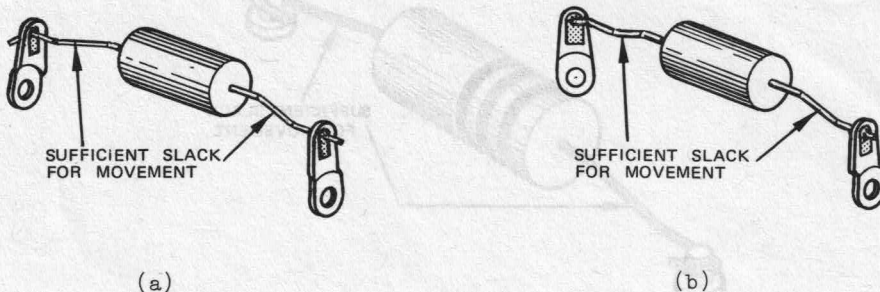


FIG. 49. MOUNTING: TERMINALS WITH COAXIAL HOLES.

- 6.6 ONE TERMINAL WITH A HOLE ONE WITHOUT.** Bend one lead around the terminal without a hole. When the terminal with a hole is parallel to the component lead as shown in Fig. 50, bend the lead so that it passes along one face of the terminal and then through the hole. When the terminal with a hole is at right angles to the component lead, pass the lead straight through the hole.

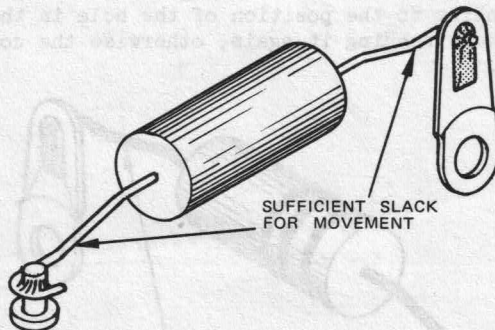
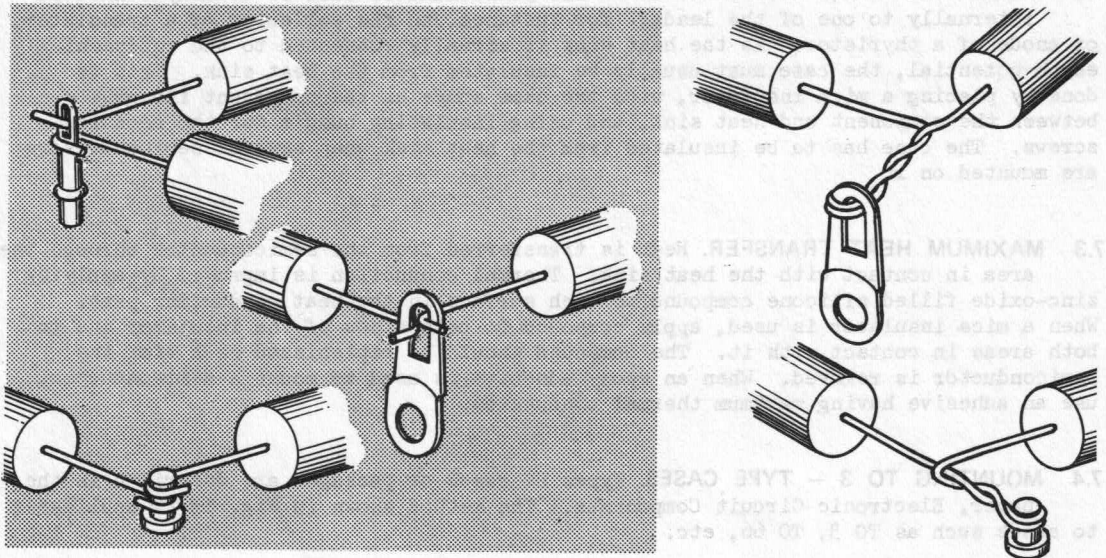


FIG. 50. MOUNTING: ONE TERMINAL WITH A HOLE, ONE WITHOUT.

- 6.7 SEVERAL LEADS ON ONE TERMINAL.** When terminating several leads on one terminal, connect each lead separately, as shown in Fig. 51a. These methods allow single components to be easily removed. It is difficult to remove components when the leads are twisted together (Fig. 51b).

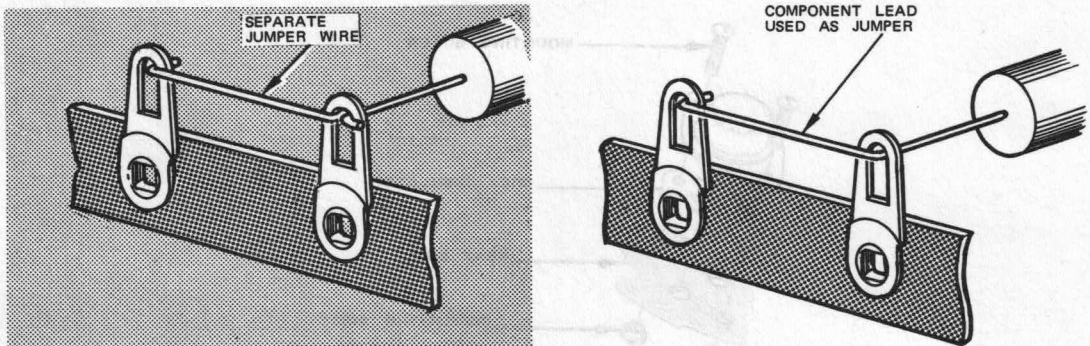


(a) Correct.

(b) Incorrect.

FIG. 51. CONNECTING TWO LEADS ON ONE TERMINAL.

6.8 INTERCONNECTION BETWEEN TWO TERMINALS. Use a length of wire between the terminals (Fig. 52a). Do not use component leads to provide the interconnection as shown in Fig. 52b.



(a) Correct

(b) Incorrect

FIG. 52. INTERCONNECTION BETWEEN TWO TERMINALS.

7. MOUNTING LARGE SEMICONDUCTORS.

7.1 GENERAL. Low power semiconductors have sufficient mass and surface area to dissipate heat generated at the junctions, but high power devices, such as power transistors, thyristors, and rectifiers, etc., require additional heat radiation surfaces, and are usually mounted on heat sinks. Heat sinks are described in the paper, Electronic Circuit Components.

7.2 INSULATING FROM THE HEAT SINK. The semiconductor case is usually connected internally to one of the leads; for instance, to the collector of a transistor, or anode of a thyristor. As the heat sink is normally connected to the equipment earth potential, the case must usually be insulated from the heat sink. This is done by placing a mica insulator, with the same shape as the component flange, between the component and heat sink, and using insulating bushes for the mounting screws. The case has to be insulated from the heat sink when several semiconductors are mounted on it.

7.3 MAXIMUM HEAT TRANSFER. Heat is transferred from the semiconductor through the area in contact with the heat sink. Thermal conduction is improved by applying zinc-oxide filled silicone compound to each surface in the heat conducting path. When a mica insulator is used, apply compound to both sides of the insulator and to both areas in contact with it. The compound should be replenished each time the semiconductor is removed. When an epoxy adhesive is used to mount a semiconductor, use an adhesive having maximum thermal conduction.

7.4 MOUNTING TO 3 - TYPE CASES. Types of cases or packages are described in the paper, Electronic Circuit Components. The method shown in Fig. 53 is applicable to cases such as TO 3, TO 66, etc.

Do not overtighten the mounting screws, otherwise the semiconductor chip may be damaged. Ensure that there are no burrs on the holes in the heat sink as these can bridge the insulation between the heat sink and semiconductor.

To terminate a lead on to the element connected to the case, place a solder terminal on a mounting screw and hold it in place with an additional nut. Never solder a TO 3 case to the heat sink, as the heat can damage the semiconductor.

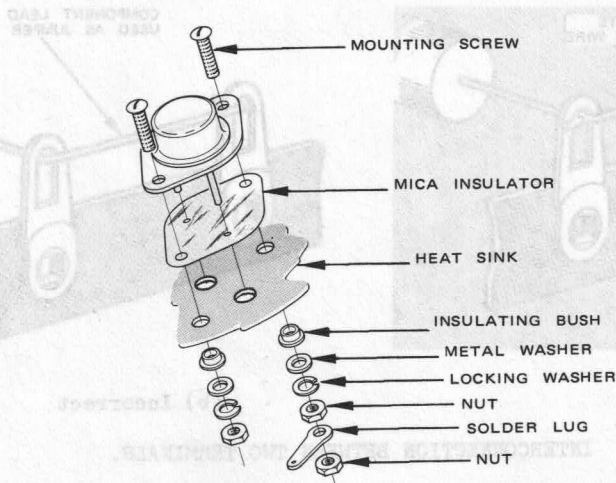


FIG. 53. MOUNTING TO 3 - TYPE CASE.

7.5 MOUNTING STUD-MOUNTED CASES.(Fig. 54). For maximum transfer of heat, at least one-half of the flange area should be in thermal contact with the heat sink.

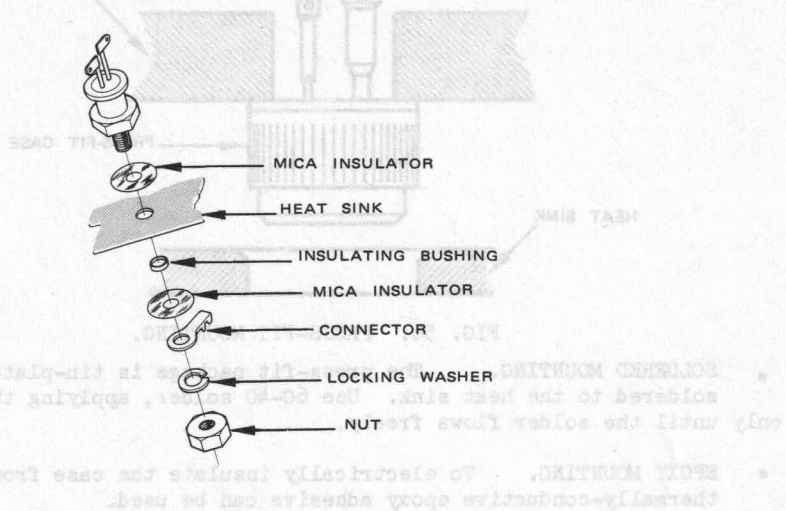


FIG. 54. MOUNTING STUD-MOUNTED CASE.

7.6 PRESS-FIT CASE. Fig. 55 shows a typical press-fit case.

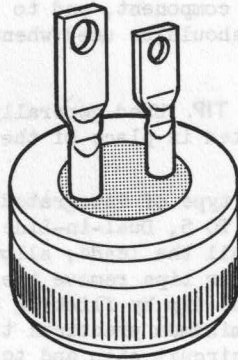


FIG. 55. PRESS-FIT CASE.

- **PRESS-FIT MOUNTING.** Fig. 56 shows a method of press-fit mounting. When the case is forced into the hole in the heat sink, metal from the heat sink flows into the knurl voids. The resultant close contact between the heat sink and the case ensures low thermal resistance.

The diameter of the heat sink hole should not be much larger than the diameter of the case, and should be slightly chamfered to help centre and guide the case. The diameter of the hole in the insertion tool should be large enough to prevent direct pressure on the leads or on the glass seal.

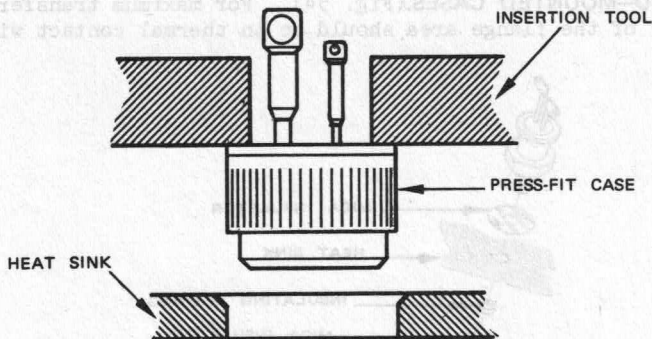


FIG. 56. PRESS-FIT MOUNTING.

- **SOLDERED MOUNTING.** The press-fit package is tin-plated to allow it to be soldered to the heat sink. Use 60-40 solder, applying the soldering tool only until the solder flows freely.
- **EPOXY MOUNTING.** To electrically insulate the case from the heat sink, a thermally-conductive epoxy adhesive can be used.

8. DESOLDERING.

8.1 GENERAL. It is possible to remove leads while the solder is molten. However, this is not the best practice because a component may be damaged by the amount of heat produced by this method. Also, flexing of the leads may cause damage to the leads, to the lead-body seal on the component, and to the terminal. Several desoldering aids are available and should be used whenever damage could result from this procedure.

8.2 MULTI-CONTACT DESOLDERING TIP. Used generally for desoldering integrated circuits, these tips are inserted in place of the normal soldering tip in a soldering tool.

The face is shaped according to the type of integrated circuit package being desoldered. Fig. 57 shows tips for TO 5, Dual-in-Line and Flatpack cases respectively. The latter tip melts the solder at all the leads, allowing the case to be removed while the solder is molten. The other tips remove the solder by capillary action; the molten solder is removed from the tip by flicking it into a suitable receptacle. Apply the tip to the joint for the minimum practical time, as it can easily cause permanent damage to the integrated circuit chip and to the board.

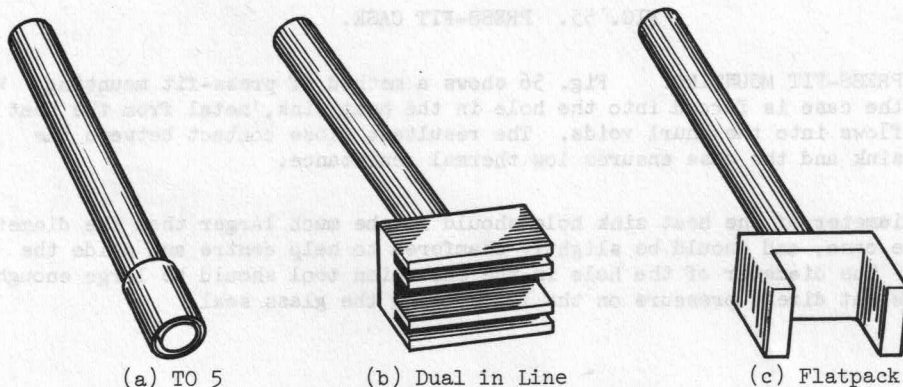


FIG. 57. MULTI-CONTACT DESOLDERING TIPS.

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8.3 AIR-OPERATED TOOLS. These tools withdraw the molten solder from the joint by the movement of air. The method used to produce this movement of air depends upon the design of the tool.

The type of tool shown in Fig. 58 is set by depressing the plunger at the top. Some tools use a lever. A heated soldering tool is applied to the joint, and when the solder has liquified, the aperture in the desoldering tool tip is placed on the joint and the release button depressed. The rapid movement of air into the tool draws the molten solder into it. When the solder has solidified in the tool it is removed by gently tapping the tip on the work bench.



FIG. 58. PLUNGER OPERATED DESOLDERING TOOL.

The tool shown in Fig. 59 produces the movement of air when finger pressure on the rubber bulb is removed. The bulb may either be attached in place of the normal soldering tip as shown, or may be attached to the soldering tool handle. In the latter case, there is an aperture in the face of the tip.

The heated tip is applied to the joint, and when the solder has liquified, finger pressure is removed from the bulb. This draws the solder into the tool. Eject the solder into a suitable receptacle by pumping the bulb. The use of this tool permits one hand to be free.

A range of tip apertures is available; a tip aperture of 3.2 mm is suitable for most printed board work.

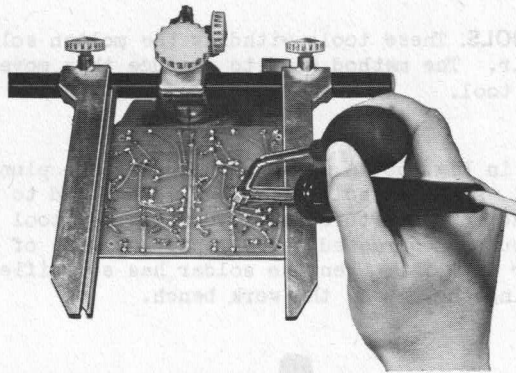


FIG. 59. BULB OPERATED DESOLDERING TOOL.

8.4 TREATED COPPER BRAID. Solder can be removed with the use of copper braid that has been treated with flux. This braid is available commercially, although braid can be fluxed by dipping it in a 75% saturated solution of rosin in methylated spirits, and allowed to dry before use.

Place the braid around the lead (Fig. 60). When the soldering tip is applied to the braid it absorbs the molten solder. The braid is removed from the joint, and the section containing the solder is cut off and discarded.

This procedure is repeated for each lead, after which the component should be readily removed. Fig. 60 shows this process with an 8 lead TO 5 style integrated circuit; two of the leads have been desoldered.

The width of the braid used depends upon the amount of solder to be removed.

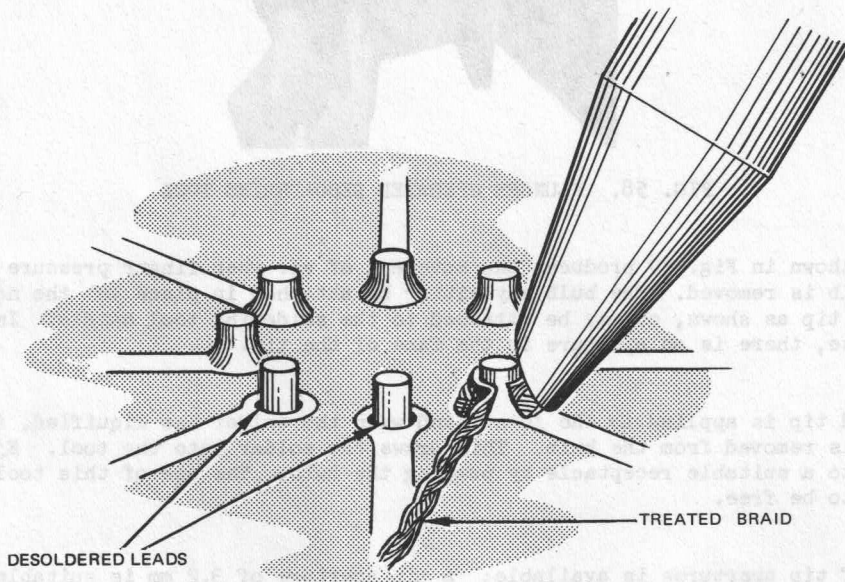


FIG. 60. USING TREATED BRAID.

9. REMOVING COMPONENTS FROM PRINTED BOARDS.

9.1 PRINTED BOARD HOLDER. As shown in Fig. 61 a printed board holder frees both hands, making the job easier. When a holder is not available, a vice can be used to hold the board, provided soft packing pieces are used and care is taken not to overtighten the vice as this can crack the board. Generally, this method is not recommended and should be avoided whenever possible.

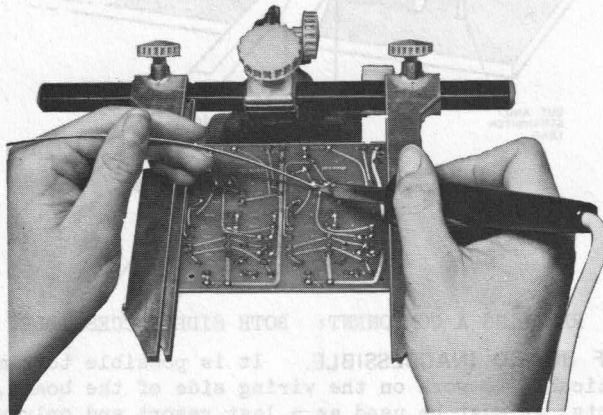


FIG. 61. USING A PRINTED BOARD HOLDER.

9.2 BOTH SIDES OF BOARD ACCESSIBLE. Where it is practicable to work on both sides of the board, there are two methods of removing components:

- Clip a heat sink on the component lead as shown in Fig. 62. Apply heat to the lead and remove the solder. Repeat the process with each lead and remove the component, taking care not to damage the printed wiring.

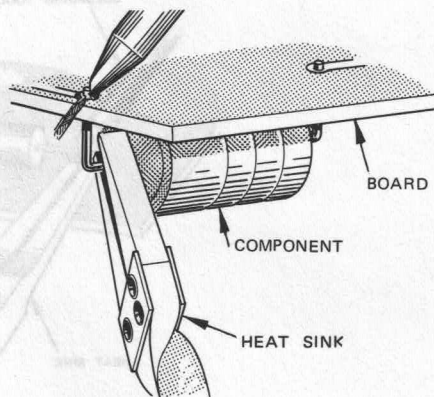


FIG. 62. REMOVING A COMPONENT: BOTH SIDES ACCESSIBLE. METHOD 1.

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- Cut the leads close to the component and then straighten them, taking care not to lift the printed wiring (Fig. 63). Cut the leads close to the board and remove the solder. Reapply the soldering iron, tapping the board to eject the stubs, and to remove any solder remaining in the holes.

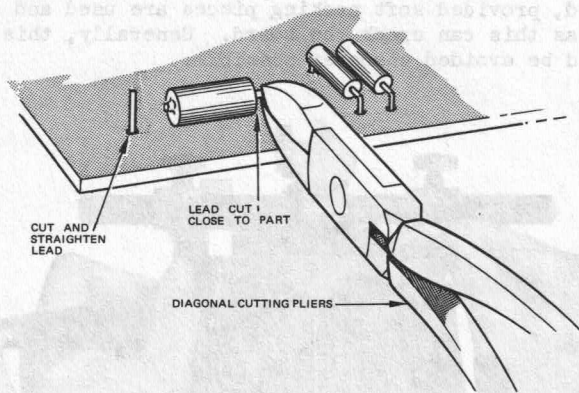


FIG. 63. REMOVING A COMPONENT: BOTH SIDES ACCESSIBLE. METHOD 2.

9.3 WIRING SIDE OF BOARD INACCESSIBLE. It is possible to remove components when it is not practicable to work on the wiring side of the board, but as this method can produce dry joints, it must be used as a last resort and only when it has been definitely established that the component is faulty.

Cut the leads close to the component (Fig. 63), or when it is difficult to cut the leads off close, cut the component in two. Straighten the wires perpendicular to the board, taking care not to lift the printed wiring.

Bend hooks on the leads of the replacement component (Fig. 64a) and slide it over the perpendicular wires (Fig. 64b).

Bend the perpendicular leads at the joint to prevent them falling through the board or moving, which could cause dry joints. Solder quickly, with a hot iron. Cut off the excess wires.

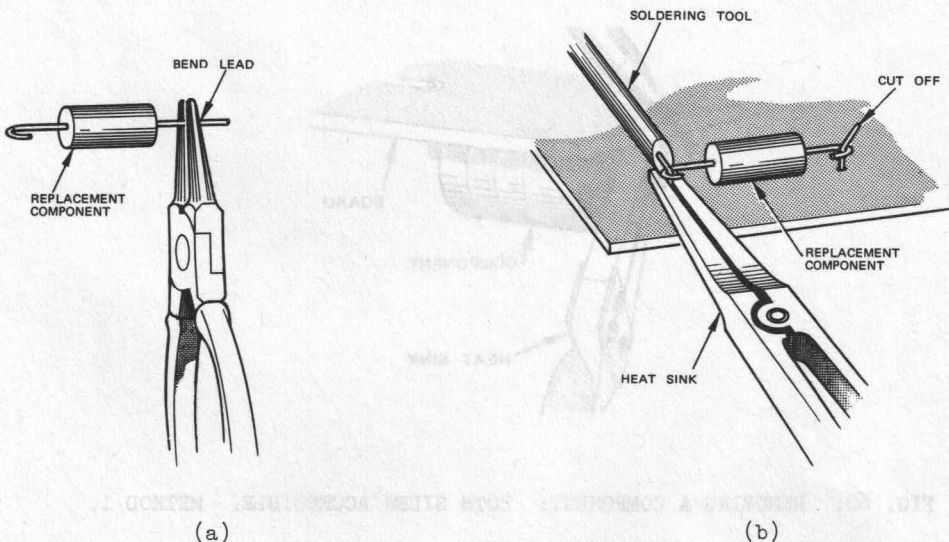


FIG. 64. MOUNTING REPLACEMENT COMPONENT.

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9.4 COMPONENT SIDE OF BOARD INACCESSIBLE. Remove the solder from all the leads, and with pliers of sufficient length, carefully withdraw the component. When it is impossible to reach the component, remove the board from its mounting and use a printed board holder.

- **UNCLINCHED LEADS.** Some manufacturers solder component leads to the land without bending (clinching) them. Remove most of the solder from each lead, check that none is attached to the copper, and withdraw the component. Remove any solder remaining in the mounting holes.
- **CLINCHED LEADS.** Some manufacturers bend (clinch) component leads on the copper side of the board. Remove most of the solder and with a minimum application of further heat, insert a flat blade under the lead as illustrated in Fig. 65. Straighten the lead by twisting the blade, keeping the edge of the blade against the lead where it leaves the hole. Repeat for each lead. Check that none is attached to the conductor and withdraw the component. Remove any solder remaining in the mounting holes.

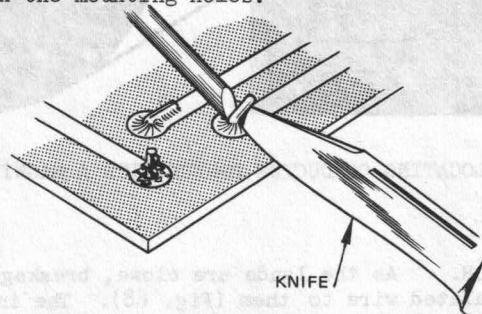


FIG. 65. STRAIGHTENING CLINCHED LEADS.

10. PRINTED BOARD MAINTENANCE.

10.1 GENERAL As mentioned in Para. 5.1, printed boards consist of selectively etched copper conductors placed on either one side or on both sides of insulated board, or on a number interconnected layers.

This Section describes the principles of working on single-sided boards. The principles are applicable to double-sided and multilayer boards, but these are not as easy to maintain, and are generally designed to be replaced as a unit when faulty.

10.2 BROKEN AND DAMAGED CONDUCTORS. As the copper conductors on printed boards are thin, mishandling or scratching the surface can damage, even break, conductors. As shown in Fig. 66, any damage reduces the cross-sectional area of the conductor.

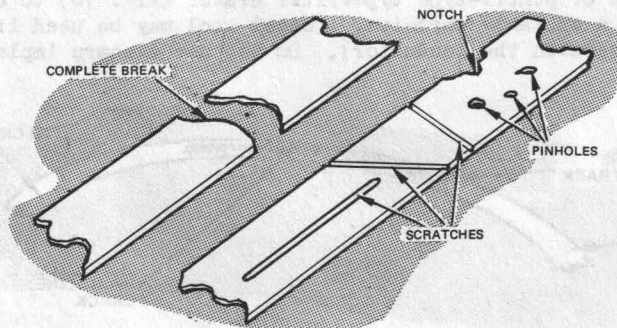


FIG. 66. CONDUCTOR DAMAGE.

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- **LOCATING DAMAGE.** As conductors are relatively small, it is difficult to locate precisely any damage. Fig. 67 illustrates the advantage of using a magnifying lens; the task is sometimes made easier by placing a light behind the board.

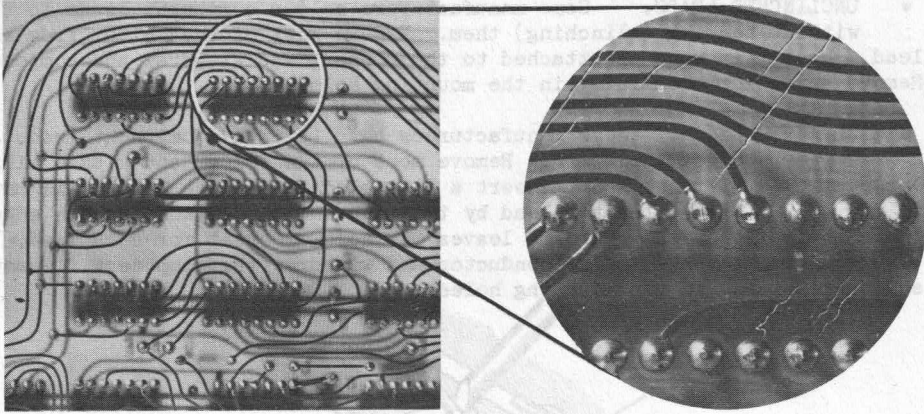


FIG. 67. LOCATING CONDUCTOR DAMAGE WITH A MAGNIFYING LENS.

10.3 REPAIRING DAMAGE.

- **SHORT CONDUCTOR.** As the lands are close, breakages may be repaired by soldering insulated wire to them (Fig. 68). The insulation prevents contact with adjacent conductors if the wire is accidentally moved.

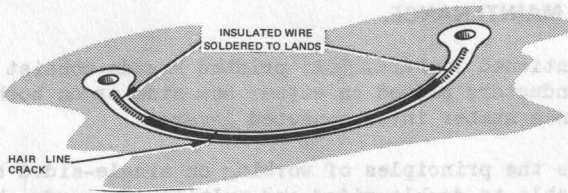


FIG. 68. REPAIRING CRACK WHEN LANDS ARE CLOSE.

- **LONG CONDUCTOR.** As the lands are distant from the fault, solder a piece of tinned copper wire across the crack (Fig. 69). Clean the track for $\frac{1}{4}$ " on either side of the crack before soldering to ensure a good join. Use a suitable solvent or pencil-type typewriter eraser (Fig. 70) to clean the track. This eraser has a suitable abrasive. (Steel wool may be used if care is taken not to further scratch the conductor). Do not use a sharp implement, such as a screwdriver.

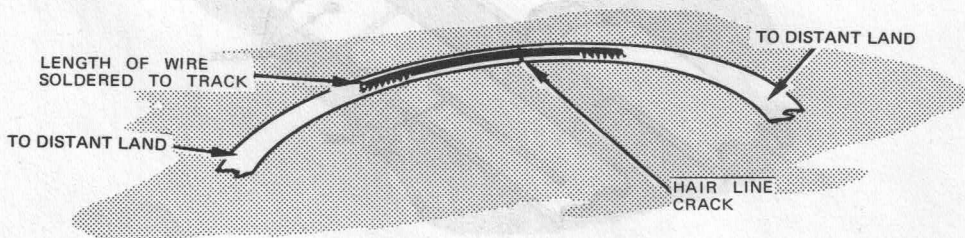


FIG. 69. REPAIRING CRACK WHEN LANDS ARE DISTANT.

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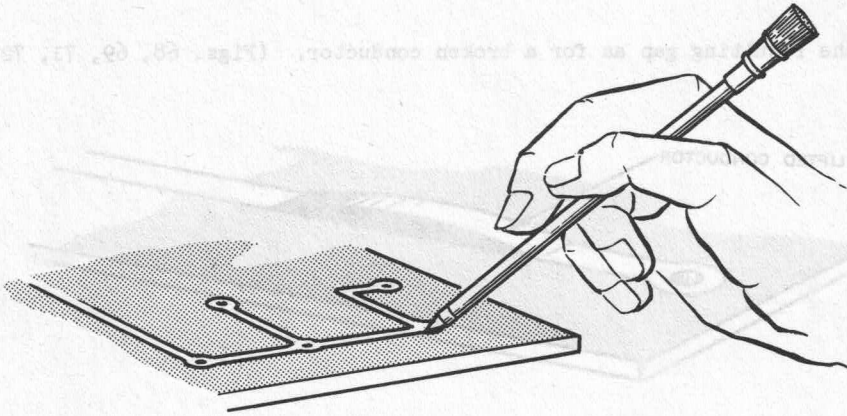


FIG. 70. CLEANING CONDUCTOR WITH TYPEWRITER ERASER.

When it is possible that soldering will cause the conductor to lift off the board, the bridging wire should be mounted on the opposite side of the board. Drill a hole (No. 63) on each side of the break on the conductor centreline, clean the conductor area beyond each hole and form a piece of tinned wire as shown in Fig. 71. Use insulated wire when repairing a double sided board in this manner.

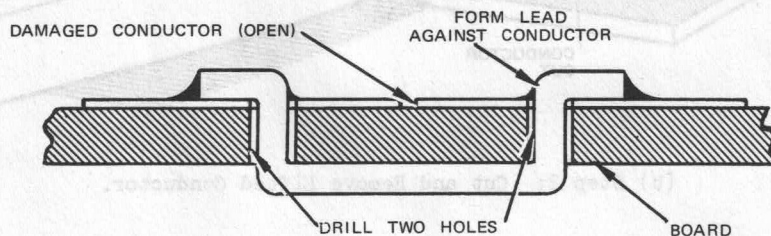


FIG. 71. FORMING LEAD ON COMPONENT SIDE OF BOARD.

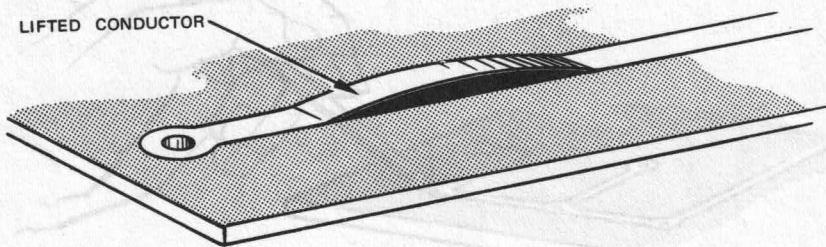
10.4 CONDUCTOR LIFTING. Conductors can lift off the board because of:

- **PHYSICAL ABUSE.** The adhesive attaching the copper to the board can withstand forces up to 70 kPa. With narrow conductors, only a relatively small force need be applied to separate the copper from the board. This usually occurs when removing components, with leads being strained while not completely unsoldered from the copper.
- **EXCESS HEAT.** The force that the adhesive can withstand decreases with increasing heat, which depends upon temperature and soldering time. To prevent the conductor lifting, solder quickly with a clean, hot tip using the minimum amount of solder. A badly-faced or cool tip increases the time that the heat is applied. Placing the tip on the lead limits heating of the conductor.

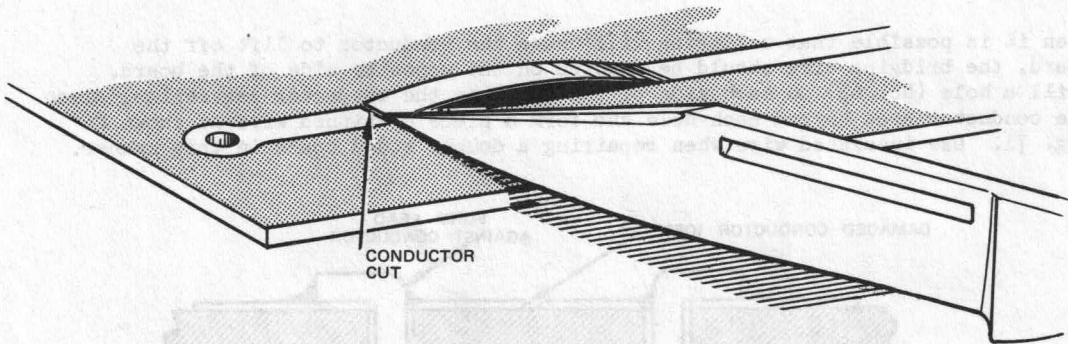
ELECTRONIC CIRCUIT PRACTICES

10.5 REPAIRING LIFTED CONDUCTOR. Cut the conductor at the point where it is still attached to the board.

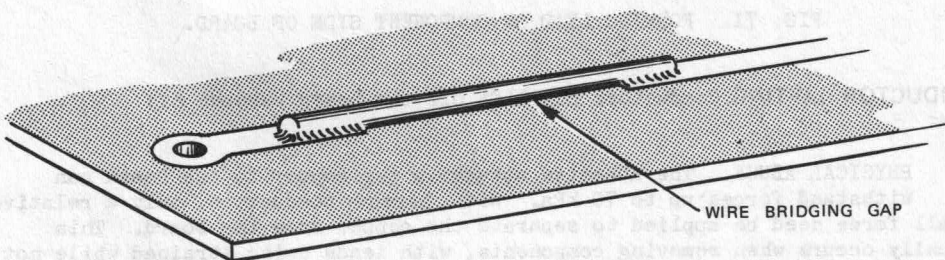
Bridge the resulting gap as for a broken conductor. (Figs. 68, 69, 71, 72).



Step 1: Locate Lifted Conductor.



(b) Step 2: Cut and Remove Lifted Conductor.



(c) Step 3: Bridge Gap in Conductor.

FIG. 72. STEPS IN REPAIRING A LIFTED CONDUCTOR.

NOTES

17. TEST QUESTIONS

1. What is meant by the term 'soldering'?
2. What is the most commonly used solder for electronic circuit work?
3. Why is this type of solder used?
4. What is the significance of the 'tin-lead' ratio, when using solder?
5. Explain why a component lead should be in contact with the conductor before being soldered.
6. Why is flux used?
7. Why should flux not be applied to the work on a hot soldering iron?
8. What are some of the causes of corrosion?
9. Name the main parts of a soldering tool.
10. What are the effects when a tool with damaged tip temperature is used on electronic equipment?
11. State two methods of controlling tip temperature.
12. Why should tools having no regulation of the tip temperature not be used on electronic equipment?
13. What is meant by the term 'tinned tip'?
14. Describe the condition of a soldering iron when it is 'tinned'.
15. Describe the recommended procedure for soldering tool tips.
16. Why should a tinned tip not be filed when the iron is cold?
17. List the steps when soldering a wire to a tag.
18. What damage can be caused when excess heat is applied to the work?
19. How can this damage be minimised?
20. Describe the appearance of a correctly soldered joint.
21. What is meant by 'tinning'?
22. Why should it be prevented for a soldering iron to be left unused?
23. What causes 'tinning'?
24. What should be done if the tip is limited to a low temperature, due to this reason?
25. What precautions should be taken when soldering KVAR's?
26. What is a single-sided printed board?

11. TEST QUESTIONS.

1. What is meant by the term 'soldering'?
2. Which is the most commonly used solder for electronic circuit work?
3. Why is this type of solder used?
4. What is the significance of the 'plastic range' when using solder?
5. Explain why a component lead should be in contact with the conductor before being soldered.
6. Why is flux used?
7. Why should flux not be applied to the work on a hot soldering tip?
8. What are some of the sources of corrosion?
9. Name the main parts of a soldering tool.
10. What are the effects when a tool with incorrect tip temperature is used on electronic equipment?
11. State two methods of controlling tip temperature.
12. Why should tools having no regulation of the tip temperature not be used on electronic equipment?
13. What is meant by the term 'plated tip'?
14. Describe the condition of a soldering tip face that is 'tinned'.
15. Describe the maintenance procedures for soldering tool tips.
16. Why should a plated tip not be filed when the face is worn?
17. List the steps when soldering a wire to (a) a tag.
(b) printed wiring.
18. What damage can be caused when excess heat is applied to the work?
19. How can this damage be minimised?
20. Describe the appearance of a correctly soldered joint.
21. What is meant by 'wicking'?
22. Why should it be prevented when soldering? How is this done?
23. What causes 'icicles'?
24. When should potentials at the tip be limited to a low value? How is this done?
25. What precautions should be taken when soldering MOSFET's?
26. What is a single-sided printed board?

ELECTRONIC CIRCUIT PRACTICES

TEST QUESTIONS (CONTD.)

27. What is a 'land' on a printed circuit?
28. What is the minimum distance that a lead may be bent from a component? Why?
29. List the precautions necessary when bending leads.
30. Why are stress relief loops used?
31. How should components be aligned on the board?
32. When mounting components, what care should be taken with regard to component markings?
33. Give two precautions that should be taken when clinching leads.
34. What is meant by the term 'unclinched lead'?
35. Why should a pair of pliers be placed on a semiconductor lead, when it is being cut?
36. How should light and heavy components be mounted on a printed board?
37. Why should a clearance be left between the end of a vertically mounted component and the board?
38. Where should the coating on a component lead finish relative to the mounting hole on (a) a single-sided board?
(b) a double-sided board?
39. What precautions must be taken when mounting a metal cased component across a conductor on a printed board?
40. Describe the correct method of forming a conductor lead at
(a) a terminal without a hole.
(b) a terminal with a hole.
41. What is the correct method of terminating several leads on to one terminal?
42. How should two terminals be interconnected?
43. Why are some semiconductors mounted on heat sinks?
44. How are semiconductors usually insulated from the heat sink?
45. What precautions are necessary to ensure that the case is insulated from the heat sink?
46. Why is a silicon compound often applied to the semiconductor and to the heat sink?
47. How is connection made to the element that is connected to the case?
48. Describe three methods of mounting a press-fit case.
49. Why are desoldering aids used?

ELECTRONIC CIRCUIT PRACTICES

TEST QUESTIONS (CONTD.)

50. When is a multi-contact desoldering tip used?
51. There are two general types of air operated desoldering tools. Briefly describe the operation of each.
52. Briefly explain how treated copper braid is used to desolder leads.
53. Why should a printed board holder be used? Why is a vice not recommended for this purpose?
54. Briefly describe the steps necessary to remove a component from a printed board when:
 - (a) both sides of the board are accessible.
 - (b) wiring side of the board is inaccessible.
 - (c) component side of the board is inaccessible.
55. What damage can occur to conductors on a printed board?
56. How is damage best located?
57. How is a broken conductor repaired when:
 - (a) the lands are close?
 - (b) the lands are distant?
 - (c) soldering may cause further damage?
58. How should a damaged conductor be cleaned before it is repaired?
59. What causes conductors to lift off printed boards?
60. List the steps taken when repairing a conductor that has lifted.

END OF PAPER.